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Economic Considerations in Closed-Circuit Television System Design

By DONALD KIRK, Jr.

During the last five years a number of systems for distribution of entertainment-type TV programming via wire to homes of paying subscribers have been successfully installed and operated. This paper considers the design and economic factors which have led to the systems currently being installed. Areas for potential improvement are outlined. Systems to provide for different billing procedures are briefly discussed. Some implications for the future are the result of this study.

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WITHIN the last ten years, closed-circuit television has become an indispensable aid to industry and management and has brought about new techniques in education. Transcontinental video transportation systems using microwave or coaxial cable have been constructed to meet the requirements of this rapidly developing phase of the television industry.

Another development is that of community antenna systems which, at the beginning of 1957, served 500 communities. A still later development, now being tested in Bartlesville, Okla., is the use of wire-television for entertainment. At this time any discussion of the economics of wire-television for entertainment must include two unknowns:

(1) How much will the American public pay for entertainment programs over a wired distribution system?

(2) What may be the costs of types of systems which may be used?

The elements of a distribution system, their design and cost aspects and interrelationships will be considered on the basis of present practice and what experience we have thus far, with the hope that some of the future of the industry will be indicated.

Presented on October 5, 1957, at the Society's convention at Philadelphia, by Donald Kirk, Jr., Jerrold Electronics Corporation, 23rd & Chestnut Sts., Philadelphia 3.
(This paper was received on September 5, 1957.)

I. PARTS OF A TV DISTRIBUTION SYSTEM

In this paper, the consideration is limited to a closed-circuit TV system used to distribute entertainment-type programming to individual homes. The four principal parts are described.

A. Display Devices

Conventional domestic TV receivers are the only economically feasible display devices. They are bought by the homeowners, thus relieving the system operator of a large capital investment. In currently operating systems, the amount of electronic equipment per viewing customer amounts to $50 to $100, exclusive of display device. The viewer's domestic receiver costs about $150. Thus, the viewers are providing more than half the required capital.

If there were to be only one channel of programming, conceivably a studio monitor or straight video display device would work. They are, however, in such limited production that they would not compete in cost with conventional TV receivers. The TV receiver, besides its advantage of multichannel operation, also uses bands somewhat removed from the video so that the fractional bandwidth of any particular band is not too wide, and so the problem of equalizing the signal over the band for each individual customer is not nearly so great.

Television receivers do impose certain limitations on the distribution system. From the standpoint of system design, it would be better if the TV receivers tuned a number of channels toward the low end of the frequency spectrum, perhaps 10 to 60 mc. This would be preferable to the arrangement currently used for off-the-air reception in which the receivers tune from 54 to 216 mc.

The ordinary TV receivers leave a great deal to be desired as to the degree of impedance match at their input terminals. This is a continual problem in system design because it means that each house drop will have a reflecting device at its terminal which will send signal back toward the feeder line. In addition, the currently available receivers leave something to be desired in the way of adjacent channel selectivity. In order to cut the cost of receivers, manufacturers have left out most of the adjacent channel trapping not necessary for air signals. If one is going to use adjacent channels on the distribution system, it is necessary to keep the relative levels of the different channels approximately equal at the receiver terminal and also to keep the level of the sound signal suppressed so that the sound signal from the next lower adjacent channel does not interfere with reception on the desired channel.

Conventional television receivers cause the system operator some expense for system performance checks. The operator usually allows the use of any conventional TV receiver and there is no measure of whether a good signal is being received from the line. Owners of poor receivers normally blame the signal supplied them, and the system operator has often to use a test set to demonstrate that the domestic receiver is at fault.

B. Transmission Lines

There are three families of devices which could be used for transmission lines in a closed-circuit TV distribution system: waveguides, open-wire lines, and coaxial cables.

To date, waveguides have been of very little practical importance. The frequencies most used for TV distribution are low enough so that a waveguide is of quite large size and very expensive. The future might, of course, see the development of waveguides filled with some sort of high permeability dielectric material which would so reduce their size that they would become economically practical. Nothing of this nature has so far appeared on the market.

Several examples of the open-wire type of transmission line have appeared in limited use in the distribution system field. From the cost standpoint, the open-wire type transmission line initially appears very attractive. For a given conductor size, or for a given copper cost, the attenuation offered by a transmission line is inversely proportional to the characteristic impedance of the line. In the open-wire configuration, the impedance may be increased and loss of the line decreased simply by increasing the spacing between the wires. A number of operators have realized this and have installed open-wire systems in which two conductors which formed the line were spaced from several inches up to as much as a foot apart.

At the present time, the possibility of building an adequate open-wire transmission line for large community system use is being studied in Los Angeles. The outcome of these tests is, of course, still open to question and conclusions must now be drawn only from tests already done. Experiments with open-wire transmission lines seem to have gone through a familiar pattern, starting with rather widely spaced lines which give high line impedance and very low line loss.

One disadvantage is that whenever it is necessary to support the wires, a shunt capacity is placed across the line by the proximity of the supporting device. With the high characteristic impedance of the line, this small shunt capacity represents, at the higher frequencies, a serious discontinuity which causes radiation which is not permissible, and also causes impedance irregularities which tend to cause ghosting of the pictures. With the low loss attained with open-wire line, this ghosting becomes particularly noticeable.

The solution to both of these problems is to reduce the spacing between the wires. This cuts down the radiation loss at a discontinuity and reduces the impedance irregularity caused by a given magnitude of discontinuity by reducing the characteristic impedance of the system. With the wires closer spaced, however, it is necessary to put more supporting members between the lines to make sure that they do not touch during high winds. Also, the low loss attained with the more open wire is now forfeited because the characteristic impedance has been decreased.

In community antenna systems open-wire line is used only for very long runs where population density is low and a great many miles of system must be put up for very low cost. The amount of picture degradation that is attributable to the open-wire type of construction is usually thought to be justified by the lower initial cost of the installation. Frequently, operators have installed open-wire line in areas of somewhat higher population density and found that over a period of time there are so many complaints about picture quality that it was thought to be cheaper in the long run to go back and replace most of the open-wire with coaxial cable.

The single "surface wave" transmission line, or "G" line as it is called, represents a special type of open-wire line in which effectively one of the wires has been removed to an infinite distance. This serves to emphasize all of the problems in connection with discontinuities on the line. At the present time there are several systems in operation employing "G" line for mountain runs. The reports on these systems seem somewhat conflicting: on one hand, it is stated that there is no problem with radiation from the "G" line; then in the same article, it is noted that a customer tap can be provided by an antenna pointed toward the line.

A very large portion of the present TV distribution systems use coaxial cable as the transmission line. Until some other type of transmission line proves itself in application, the economics of distribution systems will revolve to a great extent around coaxial cable and its characteristics. At present, there are perhaps a dozen different varieties of coaxial cables used in community systems and each is made in several different sizes.

The center conductors of the cables are generally either solid copper or a copper weld wire. The insulation between center and outer conductor may be solid polyethylene, foamed polyethylene, a filament of polyethylene wound about the center conductor, a filament of polystyrene wound about the center conductor, a series of polyethylene or other type of beads around the center conductor or other types. The outer conductor of the coaxial cable may be either a single or double layer of flexible copper braid, a copper strip, or an extruded aluminum jacket.

Each of these types of cable has its own problems not only as to first cost, but also as to installation and maintenance costs.

Almost all of the community systems currently use cable with a nominal 75-ohm characteristic impedance. The uniformity of cable may be judged by measuring this characteristic impedance for any reel of cable. Most community system operators would consider a reel of cable which varied less than ± 5 ohms around the 75-ohm nominal to be good cable. Examples have been seen which varied as much as 20 or more ohms around this 75-ohm nominal. In the frequency range used, all of the cables will have an attenuation characteristic that varies as the square root of frequency. Cable also has a temperature coefficient such that the attenuation at any one frequency expressed in db will change $\frac{1}{10}$ of 1% for every degree F change of cable temperature.

Many of the problems of distribution system design are based on these three characteristics of cable, that is, variations of characteristic impedance around its nominal, variation of attenuation as a function of frequency, and variation of attenuation as a function of temperature.

C. Amplifiers

There are three types of amplifier equipment to consider here:

(1) True amplifier equipment which increases the level of the signal.

(2) The equalizer device which changes the characteristics of a uniform amplifier to make the overall characteristic of the pair the inverse of the attenuation of a length of cable. These two devices are often combined and referred to as an amplifier.

(3) Control equipment which assures that the amplifier is operating in its proper range by measurement and adjustment of its output signals.

The wide variety of amplifiers made and used for TV distribution systems may be divided into two groups for discussing their limitations. One group is the single-channel amplifier which handles only one television channel; the other is a multichannel amplifier which handles more than one television channel simultaneously. For good reasons, each type is used in most distribution systems at one place or another. The choice of type of amplifier depends upon whether one is building a long distance transportation line or a short distribution line.

For the long runs, such as cross-country, practically all amplification is achieved in single-channel amplifier devices, but for the short distribution system, such as in a small apartment building, the advantages are largely with multichannel amplifiers. For community television systems involving both transportation and distribution, many combinations have appeared which use strip or single-channel amplifiers in part of the system, and multichannel amplifiers in other parts of the system.

In addition to general requirements of a high degree of stability and low maintenance costs, there are of interest to the designer at least five important electrical characteristics: noise characteristic, cross-modulation characteristic, spurious beat characteristic, its amplitude and phase response, and the control devices required. The choice of amplifiers for different types of systems is affected in different ways by these performance considerations.

The noise limitation applies almost universally for single or multichannel amplifiers and without regard for band location. In long runs, the signal-to-noise ratio of the system tends to be degraded 3 db every time the number of amplifiers is doubled. This fact, together with knowledge of the inherent noise of an amplifier under consideration, allows a system designer to compute the input level he must provide to any amplifier to insure adequate overall system signal-to-noise ratio.

The cross-modulation limitation appears to act differently in single-channel amplifiers than in multichannel amplifiers. Cross modulation is the third or higher odd order type of intermodulation in which the amplitude of one carrier is affected by the amplitude of a separate carrier in the amplifier. In a multichannel amplifier this appears first as a super position of the video information of one channel on that of another and shows up as a "windshield wiper" on the picture. In single-channel amplifiers, this generally shows up first as a cross modulation of the picture on the sound carrier and results in "sync buzz" if it becomes severe. In general a considerable amount of cross modulation of this type can be tolerated in the single-channel amplifiers because of "limiting" used in recovery of the sound information in the TV receiver.

The spurious-beat type of limitation does not appear very serious in either single- or multichannel types of amplifiers so long as they use the regular TV bands. This is due to the fact that second order beats, beats produced by the square law characteristic of the tubes used, are of the type $a + b$ or $a - b$ (in which a and b are the frequencies of the two carriers). For two bands, one from 54 to 88 mc and one from 174 to 216 mc such as occur in the TV spectrum, the $a + b$ and $a - b$ beats which are most important are between picture carriers and fall outside of the bands. Spurious beats due to third and higher order curvature of the tube characteristics would produce beats (for examples, such as $2a \pm b$) and some of these beats can fall inside the television band. When this is the case, however, it means that the third order curvature is significant to the extent that cross modulation will generally appear before the spurious beat appears to give trouble.

By lowering the signal enough to eliminate cross-modulation effects, the spurious beat effects in an on-channel system can be eliminated. Spurious beats, as discussed here, are not unimportant if channels other than the regular TV channels are to be used. For example, if sub-channels from 10 mc up to 50 mc are used in the same system which uses channels from 54 to 88 mc, then difference beats in the 54 to 88 group will fall in the 10 to 50 group. The same thing happens when channels between Ch. 6 and Ch. 7 are used (that is, channels between 88 and 174 mc). For any of these cases, a system designer should know the characteristics of his amplifier well enough to pick frequencies and operating levels so that the spurious beats do not give trouble.

The amplitude and phase response of the amplifiers under consideration are very important. These response curves must be adjusted to be the inverse of the response produced by the attenuation of the cable. In practice it is necessary that amplitude and phase response actually be adjusted in the field installation. With one type of cable which is often found in community systems the loss at Ch. 6 is of the order of 100 db per mile. Thus, for a system ten miles long there is a 1,000-db loss which must be removed by amplifiers placed along the cable. If the cable loss were to vary 1% from the nominal loss used in calculations, the error over this distance would amount to 10 db and field adjustment would be required to suit the particular amplifiers to the particular cable.

In a long system the sum of the gains of the amplifiers found in cascade is not a constant. It varies with tube ageing, line voltage and the like. Neither is the attenuation of the cable a constant. It varies with temperature from night to day. If amplifiers are to remove the effects of the cable then they must be continuously adjusted to compensate for tube ageing and for temperature changes. This is usually accomplished by measuring the amplitude of one or more signals going through both the cable and the amplifiers and adjusting the gain and frequency response of the amplifiers to correct the levels of the signals at the output. In amplitude and phase response and control characteristics, there is considerable variation between what can be achieved with a single-channel and multichannel amplifiers.

Most operators believe that single-channel amplifiers present a considerably greater problem as to maintenance of their amplitude and phase response than do multichannel amplifiers. On the other hand, single-channel amplifiers are more flexible in control possibilities, and for this reason are often used.

D. Interconnecting Devices

The TV distribution system designer also needs a variety of passive devices for interconnecting cable. For example, he requires a line splitting device which will take one incoming line and split it into two or more outgoing lines with the appropriate amounts of energy in each. With this device he creates branch and feeder lines which supply energy to the final customers.

It is normal practice to have a number of customers tapped onto each feeder line and for this a tap device is needed. In practice these are simple devices. Many of them are used in each distribution system and there has been great emphasis on getting the cost of the individual units as low as possible, because of their considerable influence on the cost of a system. Some of the points pertaining to their selection will be discussed under feeder line considerations.

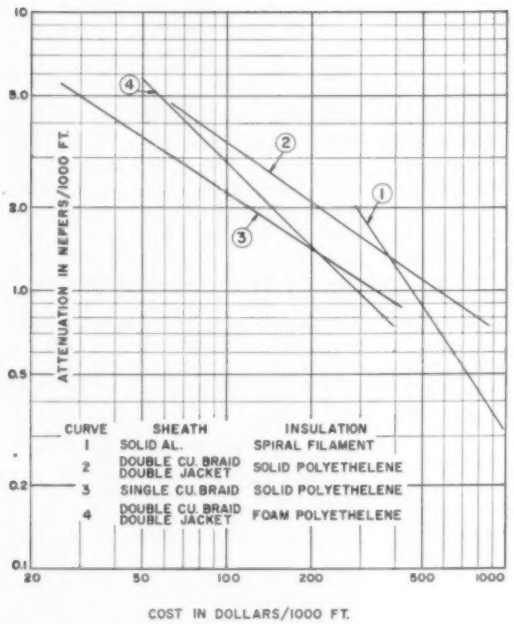

Fig. 1. Cost vs. attenuation for coaxial cable at 100 mc.
Curve 1: $P_0 = 455$, $n = 0.66$; curve 2: $P_0 = 570$, $n = 1.44$; curve 3: $P_0 = 342$, $n = 1.52$; curve 4: $P_0 = 290$, $n = 1.02$.

II. RELATION BETWEEN AMPLIFIER COST AND LINE COST

The analytical approach to economical design of a TV distribution system trunk line involves these steps:

(1) The relation between the cost of transmission line cable and its attenuation characteristics must be set down in some sort of equation form.

(2) The cost of the electronic equipment to be used in the system must also be reduced to a numerical expression which relates its gain and bandwidth capabilities to its cost.

(3) Using these expressions, equations are written for the total cost of some recognizable subdivision of the overall system.

(4) This equation giving the cost of the system is examined to find out what combination of cable costs vs. amplifier costs gives the minimum total costs. This total cost computation procedure must be followed through on both a first cost basis to determine the immediate capital requirements for installation of a system, and on a yearly cost basis to determine whether or not the long range cost of the system has been optimized.

Carrying through the above procedure results in the design of a trunk line of optimum cost proportions. The trunk line, carrying signals from one point to another, is an essential part of the distribution system, but its design is by no means the final aim. In the usual system, a trunk line goes through the center of a populated area, and along it are feeder lines branching off to provide tap-offs to individual customers. Each feeder line may be considered to supply distribution service to all of the people in an area of a certain size and for that it requires its proportional part of the trunk line. The feeder also has its own cable costs and may require some sort of tap-off device or distribution amplifier device where it is bridged off of the trunk line.

The final operation in optimizing a distribution system design is to consider the cost of the feeder along with its proportional part of the trunk line and its branching device, if any, with regard to the area which it serves. The design goal is the optimum ratio of total feeder cost to total area served. The feeder lines may be described as lines which do not have amplifiers in them, and trunk lines as lines which have no customers tapped directly into them. This definition does not come directly from some economic consideration, but is derived from field experience which shows that inserting customer taps in a line progressively degrades the quality of the picture in the line due to the inevitable small mismatch at each of these tap-off devices. When this is done a great number of times, the picture degradation can become severe. Establishing a maximum total number of customer taps in a line usually avoids the need for it to be re-amplified or makes it so that for the small number of additional customers who could be served by extending the line with amplifiers, the cost of the amplifiers is no justified.

A. First Cost of Cable

The primary step from a cost standpoint is examining the trunk line and deriving the relationship between the characteristics of cables which may be available and their cost. For the cables with which we are concerned, at any particular frequency the attenuation of the cable is inversely proportional to its diameter. Thus, if the price of a cable having one attenuation characteristic is known and the object is to find the price of one having half as much attenuation, we know that this cable with half as much attenuation will be double in diameter and will involve four times as much copper and insulating material as the known cable. If the cost of the cable is nearly proportional to its material content, the price of cable would then vary inversely as the second power of the attenuation of the cable.

In the smaller sizes of cable and especially in the braided cables, the cost of labor in manufacturing is a very appreciable part of the total cost. In this case the inverse second power rule breaks down. For any particular family of cable, the simplest method of deriving an expression for its cost in terms of its attenuation is to plot on log-log paper the cost in dollars per thousand feet as a function of the attenuation in nepers per thousand at some fixed frequency. To use this method, prices for three or four sizes of cable of a particular family must be known. Figure 1 shows this relationship plotted for four particular types of cable. For each type or family there were available four different cables.

The curves seem to justify the theory that the price of a particular cable may be expressed as:

$$P = P_0 \alpha^{-n} \text{ dollars/1000 ft}, \qquad (1)$$

where P_0 is the cost of a cable of the same type which has an attenuation of one neper/per 1000 ft at the frequency under consideration; α is the attenuation in nepers/1000 ft: and n is a constant determined by the particular type of cable.

A change of frequency can be handled by recalling that α varies directly as the square root of frequency. Thus, if the original constants of the cable are determined at a frequency f_0 and one wishes to transfer attention to some new frequency f, α must be multiplied by $\sqrt{f/f_0}$. Where the subject under consideration is the choice of an optimum value for α one may separate out frequency effects by writing Eq. (1) as:

$$P = \left[P_0 \left(\frac{f}{f_0} \right)^{\frac{-n}{2}} \right] \alpha^{-n}. \qquad (2)$$

B. First Cost of Amplifiers

Amplifier costs are not as easily determined as costs for cable, because this industry is still a very young one. In the community systems thus far installed, there are probably less than a dozen types or makes of amplifiers which represent an appreciable portion of the overall electronic equipment. These amplifiers have varied widely in both their characteristics and the jobs which they were intended to do. In only a few instances is there close similarity between the different manufacturers' specifications, and even in these cases we are hardly justified in assuming that the competitive situation and modest sales volume are such that the amplifiers' costs are related closely to their manufacturing costs. We do not know how much lower costs will be when amplifiers are made in large quantities.

We can now work only with some generalizations about the cost of amplifiers and deduce what different types of amplifiers would cost if they were manufactured under the same circumstances and were priced with the same pricing schedule.

Costs of installation of various types of community systems show that amplifier costs come in two parts: one, a nearly fixed cost, is related to locating the amplifiers; the other is variable and depends upon the characteristics of the amplifiers.

Amplifiers located on poles must be enclosed in weatherproof cabinets protected against lightning. There must be a power line and a filter to prevent transmission of r-f signals. Inside the cabinet, the a-c power must be transformed to supply filaments and plates of the amplifier tubes. Little of these costs is related to the type of amplifier to be installed. A wide range in size of regulated power supply can be provided with little variation in cost. Amplifiers, by themselves, vary in cost according to these requirements: amount of gain, output voltage and signal-to-noise ratio. For a given gain, voltage output and noise figure, amplifier costs will vary according to the bandwidths required.

For system planning purposes, it is difficult to take typical amplifiers now available and establish a cost schedule; but by assuming a quality of construction consistent with each specific type of system, we can establish a basis for considering different systems.

C. First Cost of Trunk Line

Trunk line first costs include either a conduit system or a messenger cable strung on poles to take the coaxial cable. With either of these the construction cost is an approximately fixed one regardless of the cable size or spacing of amplifiers. The design variables are cable cost and number and cost of amplifiers.

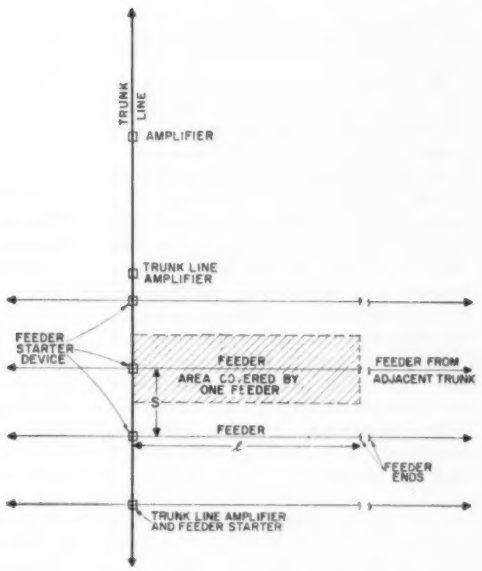

Fig. 2. Area coverage by feeders.

Assume that because of noise figure and output voltage considerations the maximum cable loss between amplifiers is L-nepers; then if the cable loss is α nepers/1000 ft, the spacing between amplifiers is given by

$$l = \frac{L}{\alpha} \text{ 1000 ft.} \tag{3}$$

If the cost of cable is given by Eq. (1), then the cost of this particular cable run will be

$$Pl = P_0 L \alpha^{-(n+1)} \text{ dollars.} \tag{4}$$

Let the cost of the amplifiers be a constant plus an amount which varies directly as the gain of the amplifier; then

$$A = A_0 + A_1 L \text{ dollars/amplifier.} \tag{5}$$

The cost of a representative section of trunk line is

$$T_t = A + Pl = A_0 + A_1 L + P_0 L \alpha^{-(n+1)} = A_0 + A_1 \alpha l + P_0 l \alpha^{-n} = l\left[\alpha\left(\frac{A_0}{L} + A_1\right) + P_0 \alpha^{-n}\right]. \tag{6}$$

The trunk line cost per thousand feet is then

$$T = \frac{T_t}{l} = \alpha\left(\frac{A_0}{L} + A_1\right) + P_0 \alpha^{-n} \text{ dollars/1000 ft.} \tag{7}$$

Optimum cable size can be determined by examining Eq. (7) for a minimum. This occurs where

$$\frac{A_0}{L} + A_1 = nP_0 \alpha^{-(n+1)} \tag{8}$$

and the best cable size has an attenuation of

$$\alpha = \left(\frac{nP_0}{\frac{A_0}{L} + A_1}\right)^{\frac{1}{n+1}} \text{ nepers/1000 ft.} \tag{9}$$

When the proper value of α has been determined one may compute amplifier spacing from Eq. (3), cable cost from Eq. (4) and trunk line cost from Eq. (7). Trunk line costs are used in solving the problem of area coverage. Trunk line is a variable component, and so we must use a value for T which has been increased over the value derived in Eq. (7) to include messenger wire or duct work and installation labor.

In the area coverage problem shown in Fig. 2 feeder lines of length l are spaced a distance S apart along a trunk line. Three variables add to the cost of covering the area $S \times l$: a cable of length l, one half of a trunk line of length S, and one half of the feeder starter device. (The last two items each serve two feeders; therefore, half of their cost is chargeable to each.)

The feeder starter device may be a bridging amplifier, or it may be a passive splitting device which removes energy from the trunk line to supply the feeder. A bridging amplifier cost is handled just as an amplifier on a trunk line. If a passive splitter is inserted, attenuation is caused in the trunk line, L_t. This is equivalent to using up part of the capabilities of the trunk line amplifier. The cost of the feeder starter device, B, may then be computed by adding to the cost, B_0, of the device itself an amount computed from Eq. (5) as

$$B = B_0 + \frac{L_t}{L}(A_0 + A_1 L) = B_0 L_t \left(\frac{A_0}{L} + A_1\right) \text{dollars.} \tag{10}$$

In most cases the signal level in the trunk line will be too low to allow the use of passive splitters as feeder starters, so bridging amplifiers are most often

used as feeder starters where feeders start at other than trunk line amplifier locations.

Between the output of a feeder starter and the last receiver on the feeder there are three sources of attenuation: first is the loss of a length of feeder cable, $L = \alpha l$; second is the insertion loss of all the tap-off devices feeding other receivers; and third is the tap-off attenuation of the device feeding the last receiver. As will be shown later, these last two attenuations can conveniently be lumped together. For purposes of this discussion let us assume that the feeder starter device has an output capability which is L nepers more than the required signal at the last receiver increased by the two tap-off attenuations. The cost of a feeder of length l is given by

$$F_0 = \frac{TS}{2} + \frac{B}{2} + Pl, \qquad (11)$$

where the three terms represent trunk line, bridging device and feeder cable.

For a densely settled area we are interested in the cost of coverage per unit of area which may be obtained from Eq. (11) by dividing by $S \times l$ to obtain

$$F = \left(\frac{T}{2L} + \frac{B}{2SL}\right)\alpha + \frac{P_0}{S}\alpha^{-n}$$

dollars per million square feet. (12)

An optimum value of α is found when

$$\frac{1}{2L}\left(T + \frac{B}{S}\right) = n\frac{P_0}{S}\alpha^{-(n+1)}, \qquad (13)$$

and the optimum feeder cable has an attenuation of

$$\alpha = \left(\frac{2LnP_0}{ST + B}\right)^{\frac{1}{n+1}}$$

nepers per thousand feet. (14)

This value of α may be substituted in Eq. (12) to obtain the cost of an optimum distribution system in dollars per million square feet.

D. Yearly Cost Basis

Thus far we have been concentrating on the size of cable to go with other components to yield a system of minimum first costs. This lowest first cost system will not necessarily be the least expensive when considered on a yearly basis. The most economical system on a yearly cost basis is established by these factors: interest on the capital investment, depreciation of the capital investment and maintenance of the plant. We are helped by relating these factors to the first costs of the plant.

When a piece of cable is installed, it can be predicted that some number of years later, if the system is still in existence, this piece of cable will have to be replaced either because the system can no longer be made to function, or because maintenance cost has so increased that renewing the cable is a saving compared to the increasing maintenance costs incurred by the old cable.

The effective lifetime for the type of cable in this service is not now exactly predictable. Little of it has been in service as much as ten years. Cables somewhat similar to those which are used for TV distribution systems are reported to have life expectancies of as great as twenty years. Assuming that cable has a life expectancy of ten years, the yearly depreciation charge will be 10% of its first cost. If there is a 6% interest charge on the capital investment, then a yearly charge of 3% must be added against the first cost. Actual maintenance of the cable in the field should be inexpensive, and if a figure of 1 or 2% of first costs is allowed for each year that a piece of cable is in the air there will be a yearly operating cost of 14 to 15% of the first cost of the cable.

Electronic equipment for the system cannot yet be as clearly estimated. There are two opposing points of view. First, if the electronic equipment is well built to start with, there is every likelihood that it can be maintained at approximately its original performance for at least 15 or 20 years, with replacement of few parts other than tubes. On the other hand, in a fast-growing field such as this one, the tendency has been to replace electronic equipment on a much shorter time schedule because new electronic devices are continually being offered with advantages over equipment already installed. Thus the decision must be between replacing equipment when it no longer functions according to its original specifications or when it has become obsolete because new and better equipment is available.

Today it seems wrong to assume that electronic equipment will not be obsolete in ten years. In some instances this might be reduced to as little as five years. On this basis, a depreciation rate of 15% of first costs per year seems reasonable. With this straight-line depreciation, the interest rate can be computed as was done above for cable, with 3% of first costs selected as a reasonable figure.

It is more difficult to arrive at a reasonable maintenance figure. Four factors must be considered in computing the maintenance cost of a piece of electronic equipment in field use: (1) it must be supplied with electrical power; (2) it must be furnished with tubes and other components which wear out at relatively regular intervals; (3) it must have adjustment and inspection of a routine nature to prevent failures; and (4) it must be provided with emergency service to place it back in operation when it does fail.

The first of these factors has been listed as a maintenance cost although there might be some justification for referring to it as an operating cost. There is basis for relating maintenance cost to the first costs of the equipment. This would certainly not be true if two pieces of equipment were compared, one of them having been built with added first costs to achieve lower power consumption. To relate the power consumption costs to first costs is, however, reasonable if it is assumed that the comparison is being made between electronic equipments built to the same sort of standards. In that case, the more costly a piece of electronic equipment, the more power it is likely to use.

The same sort of argument holds in a general way for the second item, that of tube replacements. In general, the more costly electronic amplifiers require more tubes and more tube replacements. The last two portions of the maintenance costs cannot properly be related to the first costs of the amplifier, part of which may well go to pay for automatic response adjusting equipment which is installed specifically to reduce routine maintenance attention.

The fourth part of the maintenance costs, restoring an amplifier to operation, is elusive. The direct part of this cost can be found from system operating and labor records. The cost of these manhours, however, is not the only operating cost incurred by equipment failure. Each equipment failure carries with it also an operating cost penalty in the form of a dissatisfaction on the part of the customers served. The costs thus incurred are hard to identify because in normal bookkeeping procedure such operating cost will show up in promotion, advertising, or public relations budgets. This operating cost also varies with the location of the failing equipment in the overall system. An amplifier's failure which puts out of service one feeder line causes a relatively small amount of inconvenience and, therefore, a relatively small operating cost penalty in customer dissatisfaction, but an amplifier failure which puts out an entire trunk line is a serious matter.

In spite of these arguments, it seems that a reasonable portion of the maintenance costs of the electronic equipment in a distribution system is related to its first costs and should be added to the depreciation and interest charges previously mentioned to write a yearly operating cost for electronic equipment in terms of its first costs. Computations made on various specific types of equipment have yielded numbers between 35 and 45% of first costs for yearly operating costs of electronic equipment.

We now have assumptions of 15% per year for cable and 40% per year for electronic equipment and can rewrite Eq. (7), applying 0.40 to the

first term which has to do only with amplifier costs and 0.15 to the second term (for cable). If the equation is optimized as before we obtain the correct value of attenuation for a cable which would allow a system to be designed for minimum yearly operating costs. It can be seen that this would increase the amount spent for cable and decrease the amount spent for electronic gear. The first costs of this system would be somewhat higher than the first costs of a system optimized only on a first cost basis. Once the computation has been carried out for trunk lines the same sort of computation may be made in exactly similar fashion for feeder lines, keeping in mind the fact that the feeder line starting device may well be a piece of electronic equipment.

E. Bandwidth Considerations

The equations developed thus far have been based on the assumption that the bandwidth of the system and the top frequency of the system are both fixed numbers. It is important to have in mind what both top frequency and bandwidth will do to the overall cost. When top frequency is a fixed number and bandwidth may be varied in order to vary the number of channels supplied by the system, the important design parameter in the cable is the fixed attenuation at the top frequency to be considered.

The cost of the amplifier, however, is still a variable. As the bandwidth of a system is increased, the cost of gain in amplifiers is likewise increased. In most systems it may be assumed that the cost of gain in an amplifier varies directly as the bandwidth. This is equivalent to writing the factor A_1 in Eq. (5) as a linear function of bandwidth. Increasing the bandwidth of an amplifier has a second effect on the price which is related to the permissible output voltage of the amplifier. As the bandwidth is increased, the composite output available from the amplifier is reduced because the greater bandwidth requires that the load impedance at the final plate circuit be reduced. In addition, as the bandwidth is increased, the number of channels which will be passing through the amplifier will be increased, and this tends to decrease the available output voltage on any one channel. This reduction of output voltage has the effect of reducing the value of L (the spacing of the amplifiers) in Eq. (5).

The effect of amplifier costs on the correct choice of cable size can be seen from Eq. (9). Here both terms of the denominator are increased by the bandwidth considerations. Thus, the cable for a wideband system will be larger than for a narrowband system. For the effect on system costs, one may refer to Eq. (7) in which the first term will be increased because $\frac{A_0}{L}$ and A_1 both increase faster than α. The second term of the equation increases because α^{-a} increases with increase in bandwidth.

F. Top Frequency Considerations

The top frequency to be transmitted on the distribution system is an important design parameter, its main effect on costs being on the choice of cable. For a fixed bandwidth and fixed output voltage there is little reason why an amplifier for 200 mc top frequency should be much more costly than an amplifier for 100 mc top frequency. (This statement, of course, does not apply to amplifiers whose basic configuration is low pass. Many of the distributed amplifiers now in use in community systems are of this type.) Where differences do exist between high-band and low-band amplifiers of the same bandwidth, the differences are largely brought about by the fact that some of the tubes which are most readily available work considerably better in low- than in high-band. This factor might tend to increase the A_1 term of Eq. (5) by some 10 or 20% in a high-band amplifier as compared with its low-band equivalent.

With the cable, the story is entirely different. As shown in Eq. (2), a change of operating frequency influences the value P_0 in the cable cost. When this is taken into account in Eq. (9) to determine the proper size of cable, one finds that a higher loss cable will be used for a high-frequency distribution system than for a low-frequency system. For a fixed maximum loss between amplifiers, this means that amplifier spacings on high channel will be less than for a low channel system. This shows up in the overall cost Eq. (7) in that both of the terms of this equation are greater when the value of P_0 is increased. The first term increases because α is increased. The second term increases as P_0 increases.

Another factor, one very hard to correlate into the cost equations, is the irregularity to be expected in the cable. When measurements are made on typical cables, one finds that the impedance of the cable tends to vary as frequencies are varied. This effect becomes much more pronounced in the region around 200 mc than it is between 50 and 100 mc. For short systems this effect may be quite unimportant, but for long systems it means that variable equalizers of some description will be needed in the system to correct for the cable irregularities. The worse the cable irregularities, the more often these equalizers will have to be installed and the more often they will have to be adjusted or checked. So far as is now known, there is no very good way of putting numbers on the cost of this equalization problem.

G. Frequency Conversion Systems

All through the system design problem one can see two strong opposing requirements: (1) supplying to the eventual display device TV signals in the regularly assigned television bands and (2) wanting to operate the system at lower frequencies where the cable attenuation is lower. A number of interesting possibilities which come under the general heading of frequency conversion systems may be suggested to meet these two requirements on a compromise basis.

In any tentative layout of a large city or several neighboring cities it becomes clear that the system designer will need some rather long trunk lines of very high reliability. These will be used primarily to take signal from the center of one part of the city to the center of another or to the center of a second city. Since the cost of terminal equipment for these trunk lines will have very little influence on the overall cost of the trunk, one may convert the available signal at one end to a band best suited for its transmission and at the other end convert it to a frequency appropriate for distribution.

When we think of cables, we generally think of converting down in frequency to achieve this high reliability transmission link. If microwave links are a possibility, there may well be the choice of converting up to a microwave frequency. Even in the distribution system itself there are interesting frequency conversion possibilities. For example, one might say that all trunk lines worked on some subchannel frequencies, that is, channels below the regular television broadcast band, and that the signals might be converted up to television channels at the feeder starter devices which head each feeder line. Here the economic consideration is a balance between the cost of this converter device and the money saved on the lower frequency trunk line.

An extension of this idea would be to provide to the customer's house a signal on sub-channel frequencies and then provide for each set a small frequency converter very similar to the tuner now employed in the set. This allows all of the outside plant to be on low frequencies and therefore to be of minimum cost. It places a rather high cost item at each customer's set. On all of these frequency conversion systems it is hard to establish general rules, and there seems to be no substitute at this time for a detailed study of any proposed arrangement.

III. FEEDER LINE TAPS

When a tap-off device is placed on a feeder line to supply signal to an individual customer it must attenuate the signal in the feeder by the amount of energy which is diverted to the customer. In considering the feeder line cable

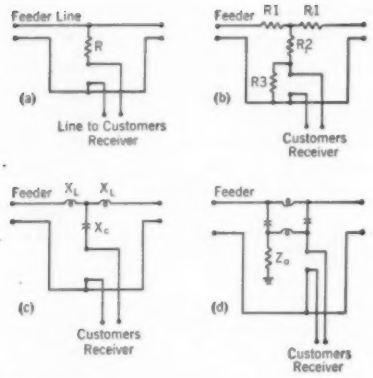

Fig. 3. Customer tap configurations.

selection we treated the sum of the attenuations introduced by customer taps as a constant by which we reduced the available output from the feeder starter device before we computed the loss that the feeder cable was permitted to have. Since the cost of buying larger feeder cable to offset tap-off attenuation represents a considerable sum, it is important that we investigate the amount of attenuation to be expected.

One very simple tap-off configuration is shown in Fig. 3 (a). In this case a resistor, R, is used to connect the center conductor of the feeder cable to the cable feeding a customer's receiver. R may be varied for taps at different points along the feeder so that it provides a current I_s to any receiver. The tap unit of Fig. 3 (a) is, of course, unmatched in all directions. A configuration shown in Fig. 3 (b) overcomes this objection by the addition of three more resistors.

In this example R_3 provides source match to the customer's house drop line, and the two resistors R_1 provide match to the incoming and outgoing feeder line. These resistors will vary (as R varies) in the amount of additional loss which they cause the tap to introduce in the feeder. To take care of this a factor k will be introduced as a multiplier for the current I_s required by the receiver line. When no effort at matching is made $k = 1$. When R_3 is added to provide source match to the house drop k is approximately 2. If feeder match resistors, R_1 are added, k will be between 2 and 3. If taps are not made in a very large number of sizes it will generally be necessary to use a tap which will provide somewhat more than the minimum value of I_s. A family of taps graded in 6-db steps would have the effect of increasing the value of k by 50%.

Assume that taps are to be installed with a density of D taps per thousand feet of feeder. Then the rate of change of current I_L in the feeder will be

$$dI_L = DkI_s\,dl + \alpha I_L dl. \qquad (15)$$

This may be integrated and subjected to the initial conditions that when $l = 0$ the line current is given by $I_L = A_{\min} I_s$ where $A_{\min}$ is the minimum attenuation factor to be introduced between the feeder and any receiver. At the other end of the feeder we have for initial conditions $l = l$ and line current $I_L = I_L$. These substitutions yield

$$l = \frac{1}{\alpha} \log \frac{kDI_s + \alpha I_L}{kDI_s + \alpha A_{\min} I_s} \qquad (16)$$

which may be rearranged to the form

$$\frac{I_L}{I_s} = A_{\min} e^{\alpha l} + \frac{kD}{\alpha}(e^{\alpha l} - 1). \qquad (17)$$

In this expression, $e^{\alpha l}$ will be recognized as the expression for cable loss. When cable loss in the feeder exceeds about two nepers $e^{\alpha l} >> 1$ and Eq. (17) may be simplified to

$$\frac{I_L}{I_s} \doteq \left(A_{\min} + \frac{kD}{\alpha}\right) e^{\alpha l}. \qquad (18)$$

Equation (18) may be interpreted to say that between the input to a feeder (supplied by a current I_L) and the last receiver on the feeder (which is supplied a current I_s) there are two sources of attenuation. One is the cable attenuation, $e^{\alpha l}$. The other is the tap-off attenuation of the device feeding the last receiver increased by a term $\frac{kD}{\alpha}$, which takes care of the feed-through attenuation of all the other tap-off devices in the line.

The total amount of attenuation which must be added to cable loss for any feeder more than about two nepers long has been plotted in Fig. 4 as a function of the tap density $\frac{kD}{\alpha}$. (The curves of interest here are the ones marked Constant Current.) Consider an example of a feeder cable where $\alpha = 2$ nepers per thousand feet. In a densely populated case there might well be 40 taps per thousand feet. Let the taps be in graded steps and assume source matched house drops ($k = 2.75$). The term $\frac{kD}{\alpha}$ has a value of about 55. If the last tap-off unit is to isolate the receiver from the feeder by 2.3 nepers (20 db) one finds from the top curve of Fig. 4 that the feeder starter device must overcome a loss of 4.15 nepers in addition to cable loss in driving the last receiver. Reducing the amount of isolation required between the feeder and the last receiver to 1.15 nepers (10 db) would mean that one could add some more taps to the end of the line. These would be high feed-through loss devices, however, and the attenuation between feeder starter and last receiver would still be 4.05 nepers plus cable loss. When one considers that in many of the systems presently operating, the feeder lines are started with a signal only about 4.5 nepers greater than that required to drive the last receivers the important effect of 4 nepers of tap-off feed-through loss on required cable size can readily be seen.

An examination of the basic troubles in a resistive tap device shows that its high feed-through loss stems from the fact that it subtracts a constant amount of current from the line regardless of how much power it must dissipate internally. Figure 3 (c) shows a tap in which the connecting impedance (X_c) is a reactance which can provide attenuation without using up line power. Compensation for the reactive component of the current drawn through X_c is provided by the dual reactances X_L.

In the example shown no attempt is made to compensate for resistive mismatch. The tap-off attenuation of this device would, of course, have a 6-db/octave slope. Over at least part of the feeder this might be desirable in that it could be used to compensate for slope in the attenuation characteristic of the feeder cable. Figure 3 (d) shows a more complicated device of the same family in the form of a directional coupler. Here all three sets of terminals may be matched to the correct impedance without requiring extra line loss in the feeder. In

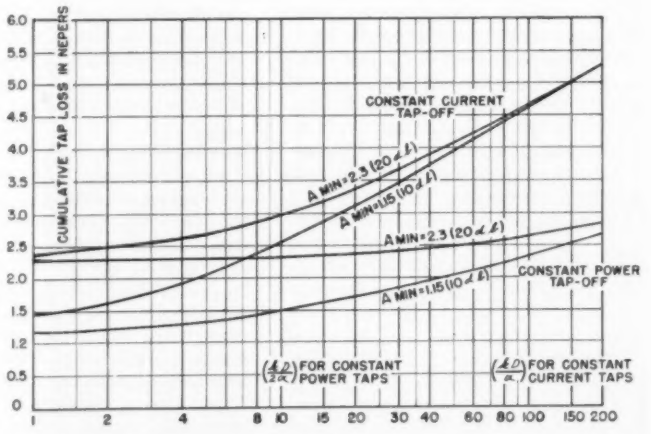

Fig. 4. Insertion loss of tap-off units.

addition some beneficial rejection of reflections from the receiver end of the house drop line may be obtained.

Let us examine the case of a graded series of tap-off devices of this constant-power type. The power supplied to each receiver will be written as P_s and a factor k will be introduced to take care of tap inefficiencies and the use of a limited number of sizes as before. The rate of change of power level in the line may be written as

$$dP_L = kDP_s\,dl + 2\alpha P_L\,dl. \quad (19)$$

Integrating and substituting limits as before we obtain

$$l = \frac{1}{2\alpha}\log\frac{kDP_s + 2\alpha P_L}{kDP_s + 2\alpha A_{\min} P_s}, \quad (20)$$

where $A_{\min}$ is now a power ratio for the last tap-off unit in the line.

Equation (20) may be handled just as was Eq. (16), and subject to the restriction that $e^{2\alpha l}$ is greater than about 10 (line more than one neper long) we may write the ratio of the feeder input power to that supplied to any receiver as

$$\frac{P_L}{P_s} = \left(A_{\min} + \frac{kD}{2\alpha}\right)e^{2\alpha l}. \quad (21)$$

On Fig. 4 the cumulative tap loss for constant power taps has been plotted just as it was for constant current taps. The difference between the losses of the two types, when converted into feeder cable cost, can justify a considerable amount of added cost of components in a constant-power type of tap.

IV. COST FACTORS IN BILLING SYSTEMS

In TV distribution systems for home entertainment which are currently under development, two basically different methods of billing the customer are currently being considered. These may be called the "fixed monthly charge" system and the "program-by-program billing" system. Since the billing system may impose certain requirements on the technical plant, a brief consideration of the main features of the systems is worth while.

A. Fixed Monthly Charges

Under the fixed monthly charge system the operator of a TV distribution system would put together an entertainment package which he felt was acceptable to his customers. For this he would charge them a certain sum each month. This system places no requirements on the electronic plant at all. If a customer desires service he is connected to the line. For this he pays his bill. If he ceases paying his bill, he is disconnected. This system has the advantage that it is the least expensive of any of the billing systems proposed.

B. Program-by-Program Billing

At the present time a considerable amount of attention is being given to systems which are designed around the idea that each of the programs presented on the system should be treated separately for billing purposes. Each program would carry its own individual price and the customer might choose to receive or not receive this program. This is usually presented as being a better arrangement from the customer's standpoint, but this is by no means clearly the case. It may, however, be a better arrangement from the standpoint of the operator of the system.

From the standpoint of the viewer, the program-by-program billing system might look as follows: suppose that a system is installed in which the individual viewer is asked to support a capital investment of say $100 in communication plant in order to get the signal to his house. Let us assume that his part of the cost of this plant is charged at $4.00 a month. Assume that entertainment programming is provided at his set terminal and that the cost of producing this programming is $6.00 a month. Now, let us add to the electronic plant that was provided to get the signal to the customer's terminal some sort of metering device. Most of the metering devices which have been proposed would cost $50 to $75, or $2 to $3 a month on the same basis that the original plant investment of $100 costs $4 a month. With fixed monthly charge billing, the customer would have to pay the plant cost plus the entertainment cost or a total of $10.

If the operator of the system is to do equally well with a program-by-program billing system, the customer must buy an average of $12 to $13 worth of programming each month to take care of the additional plant cost represented by the metering device at his set. If the viewer chose to watch only an average of $10 worth of programming per month, then the operator of the system would be faced with the problem of convincing the supplier of his entertainment programming that "They should play baseball for less money because not so many people are watching."

The system operator may take a different view, however. He may well feel that his customers have no basis of comparison and that if he uses correct promotional techniques he can encourage them to watch an average of $15 per month worth of programming. In the situation just cited this would clearly be to his advantage by $2 or $3 per month. For this reason some program-by-program billing system may well be tried on a significant scale in the near future. Since the designer of such a system may well be asking that his electronic plant be increased by 50% to 75% in overall cost, it is important that the cost of the set metering device be examined carefully.

Some of the set metering devices which have been proposed to date are outgrowths of the scramble broadcast decoders which have been proposed for use with standard broadcast television. With these devices the incoming signal would be modified in some fashion that would render it unintelligible and the device, when operated by the customer, would remove this modification of the signal so that it would provide an intelligible picture. In operating the descrambler, the customer would initiate the recording for billing purposes. These records might take any of several forms, including the depositing of the required amount of money in a box. With a wired system one may use types of signal modification which are not possible in the case of broadcast television. The most obvious of these is the modification of reducing the amplitude of signal to zero with a switch. Of course, operating instructions for this switch might be furnished in the form of a series of numbers, or in the form of a punch card as has been suggested for scramble broadcast technique. Likewise, evidence that the switch had been operated might be collected in the form of coins from a box attached to the switch as has been suggested for scramble broadcast.

Since the switch is really a portion of a communication system, it seems reasonable to expect that eventually it will be handled as other switching problems in communication systems are now handled and that the communication system itself will be expected to gather evidence of when the switch is operated. A variety of simple systems for doing this are available.

Suppose, for example, that when the switch whose closure was necessary to provide signal from the TV distribution system to an individual set were closed, this would operate a second switch which would turn on at that location a small low power crystal controlled oscillator which could send an r-f carrier back down the distribution system cable. This r-f carrier could be coded by both its frequency and by its modulation state. Carrier frequencies separated by 1 kc over the range of 500 to 1500 kc and carrying one of ten modulation states would be adequate to identify one customer in a group of 10,000 customers.

At some central point in a consumer group area, the signals returned by all of the feeder lines would be examined periodically by a sweeping receiver which would record the presence of any one of the possible signals as a function of the time. It seems likely that, by this plan, one could record at intervals of perhaps two or three minutes the position of the subscription TV switch on each of

as many as 10,000 receivers. Other similar recorders would, of course, take care of other sub-groups of population. The actual record would, of course, be arranged to facilitate machine billing processes.

A number of variations on this arrangement are possible. If more than one channel of subscription TV is furnished at the receiver terminals and a record is to be made for each channel, the problem becomes a little more complex and requires a little more costly equipment.

It should be noted that under the subject of frequency-conversion systems above, a system was described in which all of the external plant was run at subchannels and these were converted by an individual converter at each customer's television receiver. Such a system becomes much more attractive if one is going to use program-by-program billing, because the converter then becomes a portion of the billing device necessary at the TV receiver. A number of economies may be effected by putting the two devices together in one box with a common power supply.

V. AREAS OF FUTURE IMPROVEMENT

In the discussion thus far, we have worked out the relationship between a number of cost items of TV distribution systems, making it possible to deduce what areas can provide the greatest improvement in cost.

A. Display Device

It has been reasonably obvious throughout our discussion that if we could make some major changes in the display device or TV receiver, we might effect substantial system economies. Before considering possible improvements in a display device, let us note the requirements for implementation of these changes.

Reasons for using conventional TV receivers for a wire distribution service are that they are in wide current use, that this use results in very low cost for the amount of equipment involved, and the receiver itself represents a very appreciable portion of the capital investment in the overall system. These three factors might be overcome if the following conditions were met:

(1) Assume that subscription TV via wired systems is in widespread use in large cities.

(2) Assume that adequate capital is available to allow a distribution system operator to go into the TV set merchandising business.

(3) Assume that enough channels are available on the wired distribution system so that the programs now being broadcast on the air could be placed on the wired system in addition to the pay channels which the operator would provide. In this case, the operator might install an antenna to pick up regularly available air channels and convert them to desired frequencies and put them on the wired system. He would also feed the wired system with his premium entertainment channels. He would then make a special type of TV receiver which tuned only the channels provided by the wired system, and he would sell this or lease it to his customers. A number of merchandising schemes could probably be designed to accelerate the rate at which conventional receivers were traded in to be replaced by this new type of receiver capable of using the distribution line programs.

Before this can finally take place, however, a major legal issue must be decided. It will be clear to the broadcasters now presenting TV programs that if system operators are given the right to inject broadcast programs onto a wired system which is used to supply sets incapable of tuning the regular on-the-air channels then their business may well be in jeopardy. When the situation reaches such a point that a large percentage of the viewers of a TV broadcast station are viewing that station via a wired distribution system, the broadcasters would no doubt want some sort of assurance that new programming would not be found to occupy the channel used by their signal.

On the assumption that these necessary conditions for implementation of a change in display device might be met, let us discuss the possible improvements in the device.

It seems likely that instead of the 12 or more channels now provided in off-the-air receivers, only 7 to 10 would be needed to take care of all off-the-air channels plus two premium channels. These channels would probably start at a low frequency of 8 to 10 mc and would be spaced from that frequency up with no skips. It seems likely that serious thought would be given to removing the sound channel from the picture channel. All sound channels might well be placed on the system between 500 kc and 1 mc using 50-kc amplitude modulation channels.

If the system were designed for black-and-white only, it seems that serious attention might be given to double sideband transmission to simplify the intermediate frequency amplifier design of the receiver. It would be possible to consider system designs in which part of the channels were adequate for color transmission and part were adequate only for black-and-white transmission.

The system designer would probably welcome the opportunity to build a receiver whose input could be a well-matched shielded coaxial arrangement. In a very large system the cost of the central station equipment would be small in terms of its proportion for each customer. In this case the system designer might achieve some economies in the outside plant by processing all the video information at the central point, whether it came from off-the-air broadcast or from the system's studios, to place it on the same synchronizing signals. If this were done, there would be no need to send synchronizing signals as a portion of the video information. Such an arrangement would materially decrease the intermodulation problems encountered in wideband amplifiers. It would also make it possible to transmit to the TV receivers only one channel of synchronizing information for all of the picture channels. This might well be accomplished on another amplitude modulated carrier in the 1-mc region, or it might be done by transmitting a sine wave signal at horizontal line frequency directly on the cable of the distribution system.

If there is to be a program-by-program billing system, the necessary equipment would be integrated into the new type of receiver to be supplied.

B. Cable

While a major change in the display device used by distribution systems is not likely soon, there is every likelihood that major changes will be made in the cables, amplifiers and interconnecting devices which constitute the outside plant. Distribution systems require a large number of cable fittings. Some of the best cables now available were developed chiefly for intercity links where large numbers of fittings were not a problem. For feeder line use especially, there is needed a cable which is both low in loss and well adapted to the installation of large numbers of fittings.

In the examination of the yearly cost of operating a distribution system, a large portion of the cost of the cable appears in the depreciation charge; therefore the life of coaxial cables in distribution system service should receive a great deal of attention in the future.

C. Amplifiers

In practically all of the system studies, the major limitation imposed by the electronic equipment is that of a limited output voltage. For trunk lines this appears as a limit on the spacing between amplifiers; and for feeders, as a limit to the maximum length of the feeder. Although for trunk lines improvement in noise figure may be just as important as increase of output voltage, we can expect very little improvement in noise figure. In the case of feeder lines, the noise figures of the individual receiv-

ers limit us, and so here no improvement can be expected. Thus, the major area for work on amplifiers both for trunk line and for feeder starters is in output voltage increase.

When significant increases are made, then we can re-examine the fixed cost portion of the amplifier cost, that is the cabinet and power supply portion. If much greater spacings become possible for trunk line amplifiers, we may power the feeder starter amplifiers through the coaxial cable itself and reduce this fixed cost portion of the feeder starter amplifiers.

As more figures on actual operating costs become available to system operators, the importance of automatic control equipment and standby facilities for emergencies will become more and more apparent. This will be especially true as systems get larger.

D. Interconnecting Devices

Among the passive devices for interconnecting parts of the system, the customer tap-off is of greatest importance. Much work is needed to design a tap-off device which will introduce a minimum attenuation of the feeder line, will provide good impedance match in all directions, and will be installed at low cost.

SUMMARY

As can be seen from the discussion, a large number of economic factors influence the design of a closed-circuit TV system. In this presentation it is unlikely that we have been able to cover adequately any one of these factors. It is hoped that the discussion of the relation between the various factors will be of help to others who are making detailed investigations to design their own systems.

Television—Technological Revolution in Education?

By HARVEY ZORBAUGH

Television promises the first major technological revolution in education since the invention of movable type. Within the past six years, 136 closed circuits have been installed in educational institutions. The controversial subject of television as a technique of education is discussed in this paper.

At the February meeting of the American Association of School Administrators in Atlantic City, Charles Siepmann, at a session on "Television and the Crisis in Education," spoke to an audience that filled the 5000 seats in the auditorium of Convention Hall and clotted the exits with standees. That afternoon, hundreds were turned away from a two-and-a-half hour demonstration — live and kinescope — of closed-circuit teaching that jammed six large viewing rooms; a repeat the next afternoon again filled the viewing rooms to overflowing; a panel discussion the following afternoon played to standing room only.

Five years ago such a series of events, had it been attempted, would have attracted but a handful — a handful who would have been looked upon by most of their colleagues as deluded, if harmless, lunatics. But today the Joint Commission on Educational Television reports there are 136 closed-circuit installations in our schools and universities; 24 educational stations on the air (7 others under construction), 90% of them regularly broadcasting instructional materials to our schools, or to students enrolled in courses in our colleges; while many other school systems are being given air time by, or are buying air time from local commercial stations for educational use. And the number grows so rapidly these figures are only approximations.*

Experimentation with teaching by television already blankets the country geographically. It is rapidly working its way downward from adult education, through our professional schools and colleges, into our high schools and elementary schools. It is steadily working its way inward, from the offering of supplementary materials, to the teaching of the core of the curriculum. Here and there it already shows signs of having become accepted and entrenched as a permanent part of the apparatus of education.

TV and the Teacher Shortage

Beyond doubt, the greatest impetus to this rapidly growing interest in experimentation with teaching by television is the impending, critical shortage of qualified teachers.

We, as a nation, are committed to equal educational opportunity for all; our way of life can be perpetuated, and our national purposes realized, only as we make good on this commitment; as a people we are determined to make good on it; as individuals, to take advantage of it.

Of a population of some 168,000,000 we now have in excess of 29,000,000 in elementary schools, over 8,000,000 in secondary schools, more than 3,000,000 in colleges and universities. The number going to schools and colleges is increasing by 2,000,000 a year. By 1965, we will have 36,000,000 elementary-school pupils, 12,000,000 secondary-school pupils, 4,500,000 students in our colleges and universities.

These 12,500,000 additional students will require, under present conditions of teaching and learning, a minimum of 350,000 more qualified teachers than we now have. All present or planned recruiting and training programs are unlikely to produce more than 100,000. Almost certainly, we face a shortage of a quarter of a million qualified teachers by 1965!*

Unless the quality of our education is to suffer, we must find ways to use more effectively the fully qualified teachers we will have. Much of the experimentation with television in teaching has been directed to this end.

Three years of meticulous research at Pennsylvania State University reveal no significant differences in achievement between students face to face with their instructor in a classroom ("originating room") and those in other rooms ("viewing rooms") to whom what occurs in this classroom is relayed by coaxial cable and viewed on TV screens. This research has involved 15,500 students in 60 semester courses (many in multiple sections),

Paper presented for the Society's 1957 Convention at Washington, D.C., by Harvey Zorbaugh, Communication Arts Group, New York University, 100 Washington Sq. East, New York 3. (This paper was received on March 28, 1957.)

* Personal communication from the Joint Council on Educational Television, Washington, D.C., Mar. 1, 1957.

* Alexander J. Stoddard, *Schools for Tomorrow: An Educator's Blueprint*, The Fund for the Advancement of Education, New York, 1957.

Fig. 1. NYU Control Room.

Fig. 2. NYU Student Viewing Room.

including such diverse subjects as chemistry, music, accounting, German, air science, psychology and education.*

Pennsylvania State University's conclusions have been confirmed by experiments in many other colleges around the country. The pattern varies: from televising what occurs in a classroom and extending it to many other classrooms; through televising a lecture-demonstration, to be followed by its discussion under the leadership of instructors in the viewing rooms; to the use of television as an audio-visual aid to the instructor in a single classroom. But always, the results are the same. When compared with the achievement of students instructed in traditional ways, the achievement of students receiving all or part of their instruction by television is at least as high.

The evidence seems clear that facts, principles and basic motor skills can be taught to young adults as effectively by means of television as with an instructor facing students in the classroom. The experience of the Armed Forces confirms this conclusion. Even the skeptics are coming around. Charles Siepmann, in the address referred to above, observed: "...for some time I remained skeptical about these findings. But during the last year, I have had opportunity to test the theory that seeing, alone, is believing. I have traveled widely and observed many of these experiments in action. I came, I saw — and I was convinced. Of what? Of the fact that something is going on here of revolutionary significance to the future of education in this country...."

Much of the required core of general education is already taught by the lecture or lecture-demonstration method, as are many elective and advanced courses in the larger universities. The transition to televised instruction is not unduly difficult for either instructors or students. Certainly, televised instruction is one way to meet the impending shortage of fully qualified instructors in our colleges, extending as it does the best teaching to unlimited numbers of students. It appears likely that in the end it will prove permanently the best medium for a considerable part of instruction.

Meantime, experimentation is rapidly extending downward into the secondary and elementary schools — Pittsburgh, Detroit, Chicago, St. Louis, Cincinnati, Schenectady, Levittown, Evanston, to mention but a few of the school systems involved. Here the results are not yet in; but many of the educators involved express enthusiasm over the apparent success of these experiments. Pittsburgh and St. Louis report that TV groups learned all subjects involved as well as did the groups conventionally taught, and learned several subjects even better than the others.

It will be particularly interesting to watch the progress of the five-year experiment, underway in Washington County, Hagerstown, Md., which emphasizes "direct instruction of pupils in the basic subject matter offerings of the curriculum." At its conclusion, it will have involved all the schools in the county and their 18,000 pupils. The careful evaluation of the results, which is planned, should tell us whether television has the instructional potential in the schools that it has in the colleges. I am confident that it will.*

Testing Televised Education

The interest of educators in experimenting with television goes far beyond that of discovering its potentialities for helping to meet the impending, critical shortage of qualified teachers, however. An example is the experimentation in progress at New York University. Because of population trends in New York City, New York University does not anticipate the deluge of students that many colleges and universities will face. Yet, New York University has completed two years of full-scale experimentation with television in instruction, and is embarking on a third. Why?

At New York University, as elsewhere, educators realize that, in television, technology has given us a new medium of communication which is having a pervasive influence on every aspect of our life — social, political and economic; and that it behooves us to explore it, to learn whether perchance it may not, in many ways, enable us to do better the job it is ours to do. Experimentation is directed increasingly at exploring television's potentialities for *improving* instruction. To make it possible for unlimited numbers of students to be taught by the best teachers is, of course, to raise the average quality of instruction. But it is not to explore the unique potentialities of television for improving the quality of instruction. Let me put it this way: beyond extending the influence of the best teachers, what can television contribute to increasing the effectiveness of their teaching?

This is the question New York University has set out to answer, at least partially. To this end, it has built a studio equipped with two image-orthicon chains, a vidicon film chain, and all the supporting paraphernalia to be found in a first-rate commercial studio. The studio is staffed with a producer and three directors (all with a happy combination of professional and educational experience), three engineers and two cameramen (all with long commercial experience), and supplementary student help (floor manager, mike-boom operator, make-up artist, stagehands, etc.) from

* Personal communication from L. P. Greenhill, Associate Director, Instructional Research Program, The Pennsylvania State University, Mar. 1, 1957.

* *Closed-Circuit Television Project Notes*, Board of Education of Washington Co., Hagerstown, Md., Jan. 16, 1957.

among seniors in the Television, Motion Pictures and Radio, and the Dramatic Art Departments. Audio lines and coaxial cables connect the studio with seven viewing rooms that have a capacity of 40 students each, equipped with two 24-in. RCA receivers mounted on stands with tilt tops and industrial castors; and with an auditorium, equipped with theater projection, that has a capacity of 450 students.

Among experiments underway at New York University is one designed to test what imaginative production and direction may contribute to the effectiveness of instruction. The course involved, Man's Cultural Heritage, is taught by an instructional team of a sociologist, an anthropologist and an historian. As traditionally taught, it has consisted of two 2-hr. sessions a week: the first, a large lecture; the second, discussion in groups of 30. As televised, the first hour of each session is a lecture from the studio to the viewing rooms, followed by an hour of discussion in the viewing rooms.

The first time around on television, the studio contained only the lecturer, a desk and a blackboard, supplemented by such wall charts, maps and occasional films as the instructor was accustomed to use, simulating as closely as possible the traditional pattern of instruction. After each session, producer, director and instructional staff met for two to four hours to discuss the objectives of the session, and what imaginative production and direction (making full use of documentary and dramatic techniques, and the wide variety of auditory and visual materials — photographs, film clips, charts, models, dioramas, records, tapes, etc.) might contribute to supporting and realizing these objectives. Two members of the staff of WRCA-TV, which is cooperating with New York University in this experiment, sat through the lectures and subsequent student discussions, and participated in these planning sessions.

The second time around on television, now in progress, the production techniques agreed on by the production and instructional staffs are being used. At a recent session on religion and primitive man, for example, Pearl Primus illustrated major points with interpretative dances.

The achievement of students the first time around, when the traditional lecture was televised "bare bones," is being compared with the achievement of students the second time around. When the results are in we should have a rough measure of what production techniques contribute to the more readily measurable aspects of learning.

All over the country, from the elementary schools to the universities, experimentation is being focused increasingly on exploring the unique potentialities of television as an instructional medium.

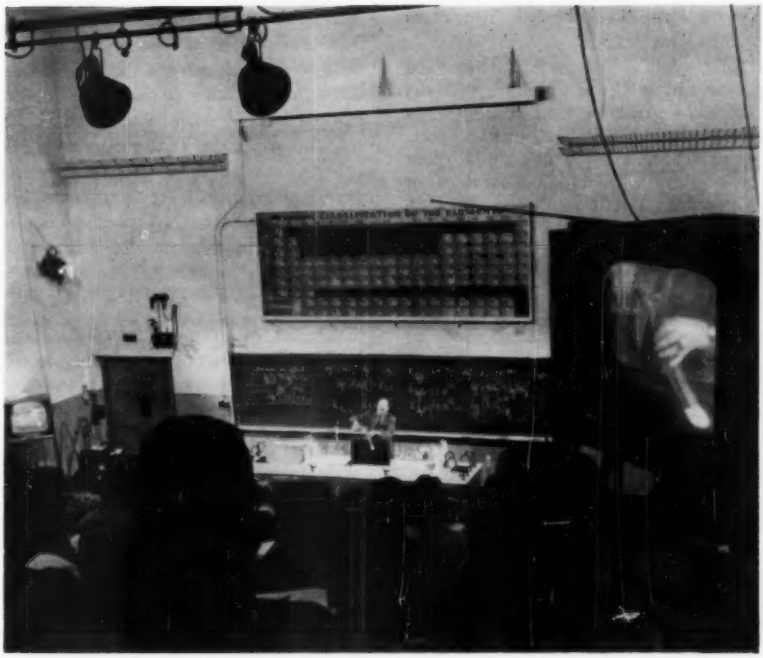

Fig. 3. Television used as demonstration magnifier in General Chemistry, at the Pennsylvania State University.

While this exploration is only beginning, it is clear already that there are areas in which television is vastly improving the quality of instruction. Science, medicine and dentistry are illustrations. The television camera and the large-screen receiver are an unrivaled device for helping students to see how things occur, how things are done.

The report on a recent survey on television in American dental schools, conducted by the American Dental Association, pointed out: "In the past... groups of only five or six students would cluster around a table or patient to see firsthand the methods described by the lecturer. This meant the instructor would have to repeat the demonstration as many as twenty times to accommodate all students in a course. Now through the medium of closed-circuit television an entire class of 90 or 100 students can watch the demonstration at a time, thereby saving as much as three week's time for one instructor."

More important, each of the hundred students has a clearer view than any one of the five or six had, when clustered about the instructor. Here television is used as an audio-visual aid to improve instruction. With the advent of color it is sure to have wide use in the sciences and training for related professions.

Anyone who has watched Dr. Harvey Elliott White teaching high-school physics in Pittsburgh, or Mrs. Anne Slack teaching French to grades 3 to 5 in Schenectady, must conclude that television promises to improve the quality of instruction at all levels, and through a wide variety of subjects.

Commenting on the results that already are in, Dean Thomas Clark Pollock of New York University, Chairman of its Committee on Evaluation, said recently: "It now seems clear... that television offers the greatest opportunity for the advancement of education since the introduction of printing by movable type. This comparison is made soberly."

Technical Problems

At the present stage of our experimentation with teaching by television, it often seems that we are uncovering problems faster than we are solving them. Some of these problems are predominantly technical, others predominantly educational, though the two are intimately interrelated. Let's look first at some of the more technical problems.

First, there is the problem of costs. To the commercial broadcaster the cost of the average educational installation, particularly the closed-circuit type, seems piddling. But to the educational administrator who must justify the cost of construction, equipment, operation and maintenance to his faculty, and to his board of education or legislature, these costs often seem prohibitive. Without the 2.5 million dollars which the Fund for the Advancement of Education, of the Ford Foundation, has invested in instruction by television since 1953, through grants to school systems and universities to help get them off the

ground, there would be little instruction by television today.

Of course, as Alexander J. Stoddard points out, it is not so much that the cost is so great, as that it is new. A closed-circuit installation costs no more, perhaps less, than is frequently spent for a library, cafeteria, laboratory or gymnasium. But it must compete with traditional items for a place in the educational budget. And, at points, costs are truly high.

Since today's schools were not built with closed-circuit television in mind, the cost of construction involved in installation is disproportionately high. Engineers, working with educators and school architects, can help materially to reduce this cost as new schools are planned and built.

Urban universities and school systems face the problem of linking buildings together over miles of city streets. New York University, for example, has six centers in Manhattan and the Bronx, the southernmost separated by 11.8 miles from the northernmost. To get from building to building in a given center requires the leasing of conduits and cables. The cost of so linking the entire university is exorbitant. It is to be hoped the process of transmitting moving images over ordinary telephone wires will materially reduce this cost; or better, that the Federal Communications Commission will authorize universities and school systems to connect their buildings by microwave.

If teachers are to learn to use television effectively, it is vital that every installation have some type of recorder — film or tape — whereby the teacher can observe and profit by his successes and failures in the use of television. Here again, costs are likely to seem out of reach. A less expensive recording device is urgently needed by educators.

Then there is the problem of equipment. It may not have occurred to the commercial broadcaster that today's equipment is fragile, complicated, and cumbersome. But this quickly becomes apparent in educational installations, in the majority of which teachers and students, with little or no previous experience, act as producers, directors, cameramen and engineers. Sturdier, simpler, more mobile equipment would be a boon to education; particularly color equipment. Education can do much with the gray scale. But there is much it cannot do; and little it could not do better with color.

A third technical problem is the reduction in communication between teacher and students. Students miss the opportunity to question and debate as the lecture proceeds; the lecturer is accustomed to gage his effectiveness by observing the reactions of his students. Experiments with two-way audio between lecture room and viewing rooms, such as those at the University of Iowa, have not been conspicuously successful. New York University is exploring with RCA the possibility of mounting a fixed camera in the viewing room which would transmit a picture of the class to a receiver, mounted on the studio camera, in which the lecturer could see his students. Perhaps this problem is insoluble, at least where any great number of viewing rooms is involved. But again, an engineering genius may come up with a solution.

A final illustration of the technical problems encountered in the use of television in instruction is the University of Minnesota College of Education's experiment in demonstration teaching. Cameras in classrooms in the University's laboratory high school transmit demonstrations of master teaching to teachers-in-training in viewing rooms. The high-school students learn to ignore the cameras, but they cannot be tied to microphones. Achieving a usable quality of sound is proving a formidable problem. An audio pickup that enables the teacher and any member of a demonstration class of 20 to 30 pupils to be heard, even when talking in low voices and from any or all parts of the room, is required. This must be accomplished without excessive background noise, and without resort to movable booms and other acoustical apparatus that would be distracting to normal classroom procedure. This problem, critical to the use of television for teacher training, has not been solved.

Educational Problems

Now let us consider, briefly, some of the predominantly educational problems we are encountering. As an illustration, I will take problems we are currently concerned with at New York University.

The relation of television to the total pattern of instruction: This may vary from using television to reproduce classroom instruction and extend it to a multiplied number of classes, to treating television as another "audio-visual aid" to be used where it proves fruitful. Is television most useful in one way or the other? Or in a variety of ways within this variable according to the instructional problems presented from one course to another, or from time to time during the instruction of a given course?

The relation of television to other particular instructional methods: In the case of composition, for example, what is the proper relationship to discussion, writing and reading? Are television and discussion most fruitfully related serially in separate sessions, or does it prove more fruitful to have each televised presentation flow directly into subsequent discussion? What is the most productive relation timewise, or proportionally, of television and discussion? How do the answers vary with the subjects and objectives of courses?

The pattern of use of instructors. This may vary from the use of a series of specialists in various areas of a course, through the use of an instructor acting as coordinator throughout the course (to introduce each TV presentation, to point it up, and to relate it to the continuity of the course) while drawing on a wide variety of specialists for contributions from presentation to presentation, to having one instructor do all the TV teaching.

The selection of content: What content proves most productive in realizing the objectives of a course when it is televised in whole or in part? How, if television is to be used fruitfully, should the instructor's selection of materials be influenced by its use? What, further, may the wide variety of auditory and visual materials available or possible, normally cumbersome and sparingly used but easily handled on television, contribute as content to forwarding the objectives of a course?

The use of professionally trained producer-directors: What has professional production to contribute to realizing the objectives of the courses? It is possible, as Pennsylvania State University has demonstrated, to extend effectively traditional instruction by television through personnel with little or no TV experience. But how much more may experienced, imaginative direction (operating through skilled video and audio engineers in the control room and experienced cameramen on the floor; experimenting with lighting, sound, use of cameras, documentary and dramatic techniques, etc.) contribute to the effectiveness of television presentation in teaching?

Personal qualities of instructors: What are the personal qualities of the instructor which determine his effectiveness in teaching by television? We have already had enough surprises, happy and unhappy, to become aware of the fact that the effectiveness of an instructor on television is not easily predicted from his performance in his accustomed teaching environment.

Size of the viewing group: What is the optimal size of the viewing group for the most effective instruction? What are the critical factors in determining the optimal viewing group? Are they technical (size and quality of the visual image; characteristics of the sound)? Or are they social-psychological (traditional attitudes toward the instructional situation; or social-interactional processes)? Or both? And how do they vary with the subject matter and objectives of courses?

Length of the television presentation: What is the optimal length of a given television presentation for instructional purposes? To what extent is it determined by the attention span of students? By their capacity for sustained close concentration? By visual fatigue? To what extent is it determined by the demands television makes upon the instructor? To what extent are these demands related to the way in which television is used in relation to the total instructional pattern?

The suitability of various subject matters, in terms both of their educational objectives and contents, to presentation by television: These variables, to point out only the more obvious, are interdependent, complex and but roughly defined. But they are the foci of problems that must challenge any school system or university seriously experimenting with the use of television in instruction. Admittedly it is impossible for a given institution concurrently to study them all. Indeed, achieving even approximate answers to the questions that arise must be the joint enterprise of all institutions experimenting with the use of television in teaching.

TV and the Teacher's Future

Merely to have raised these questions is to recognize the technological revolution with which television threatens traditional concepts and practices in education — changes in the role of the teacher, changes in methods of teaching, and so in the training of teachers, changes in curriculum, changes in administrative planning and budgeting, changes in the physical structure of school buildings.

Because educators are well aware of this, there is among them, naturally enough, considerable questioning of, and opposition to, the increasing use of television in teaching. Some of this opposition comes from those who are against any change; from among those who do not wish to be disturbed in their familar and comfortable ways; and from among those who have a proprietary, precious attitude toward their scholarly knowledge. Their counterparts in ancient Egypt are reputed to have opposed the art of writing, and in the fifteenth century, to have opposed the printing of books.

In the universities, where the supervision of teaching is not *comme il faut*, and a man can teach a lifetime without anyone's coming into his classroom to observe what he is doing, some teachers look upon television as an invasion of their privacy. The prospect of teaching on television, exposed to their peers, affects them like dreaming they are walking down a crowded street and suddenly realize they have no clothes on.

Most of the opposition, however, comes from those who see in television the threat of technological unemployment, the degradation of the teacher's status and role, or the dehumanizing of the teacher–pupil relationship.

Many are concerned lest television greatly reduce the need for professionally trained teachers, if not displace conventional teaching altogether. Last summer the American Federation of Teachers, at its 40th annual convention, unanimously resolved that whatever the usefulness of television may be as another audio-visual aid, televised instruction must not become the core of the curriculum. "We are unalterably opposed to mass education by television as a substitute for professional classroom techniques."

This, to my mind, is an idle fear. Education is more than the transmission of facts, principles and motor skills. It is also guidance in social and emotional development, in growth in maturity, in the acquisition of healthy ways of dealing with the problems of living, in the clarification of ideas about the world, in commitment to values. All this takes place in interpersonal relationships, in which good teachers always must play a critical role. The farther down in the educational process we go, the truer this is. Moreover, the impending shortage of teachers promises to be so great that, television or no television, there will be need for every competent teacher available.

Even where teachers accept this fact, they still are concerned with the effect of television on their professional status and roles. Some fear that the teacher's scholarship and skills will become subservient to the "show" as conceived by television technicians. Others fear that television, exploiting the talents of those that prove especially adept at using the medium, will degrade the status of the rest to that of monitors and markers of test papers.

There is no doubt that television will change the functions performed by many teachers. But this is not to make them less vital to the education of youth. And we who teach should remember that history clearly shows that in education, as in every field of human endeavor, new tools have always increased the importance and status of the craftsman.

Beyond these anxieties is the sincere concern of many teachers lest television dehumanize education. They contend that all learning must be an active process of give-and-take between pupil and teacher. They maintain that televised instruction, for the student, is all take and no give, a passive, unchallenging process; a sitting before viewing sets, merely looking and listening, a sterile absorption of fact and opinion.

To be sure, as a leading educator has put it, "You can't ask television a question, you can't debate it!" (Parenthetically, I would point out that the same objection could be made to books.) During the televising of a lecture-demonstration, class participation and student-teacher interaction are severely reduced. Television places a barrier between teacher and student.

All this is true. But typically, in both schools and universities, televised instruction flows immediately into class discussion where there is ample opportunity to question and debate. Moreover, wide use of television in instruction will free much time of many teachers and scholars for closer, more personal contact with individual students and for research.

The frame of reference in which this question is argued is, further, likely to be misleading. It contains the implicit assumption that, were it not for television, students in our schools and universities would be taught in small, cozy seminar-type groups. Nothing, of course, could be farther from the truth. As I pointed out earlier, much of university instruction already takes place in large lecture halls. More will. The size of classes in our schools is large, and is rising.

After 30 years experience with university teaching of large lecture groups, I can assure you it is easy to overestimate greatly the amount of student-teacher interaction that typically occurs in them. As Professor Buckler, one of New York University's television lecturers, remarked: "Is not the student closer to his teacher as a personality as he sits in a group of thirty watching and listening to him on the television screen than he would be in a group of several hundred in a large auditorium?" No one is suggesting that television be substituted for small seminars and personal contact between student and teacher. To the contrary, many educators believe that with swelling enrollments, only wide use of television, making possible more effective use of teaching staffs, offers a reasonable chance of preserving them.

The Future

This ferment is but the normal accompaniment of technological and social change. Dr. Clarence Faust, head of the Fund for the Advancement of Education, recently commented. "They say that some ancient Egyptians objected to the art of writing because it would dull men's memories. Centuries later some men fought against the art of printing because they feared it would undermine the authority of church and state. Now they are objecting to television because they think it will undermine teaching. But with the vast and urgent problems United States education now faces, American citizens cannot afford to neglect this new medium."

With continued encouragement from the Fund for the Advancement of Education, and with rapidly increasing num-

bers of educators agreeing with Thomas Clark Pollock that "It now seems clear . . . that television offers the greatest opportunity for the advancement of education since the introduction of printing by movable type," far from being neglected, it is making more rapid strides ahead. As the shadow of the shortage of teachers inches closer, more and more schools and colleges are declaring their intentions of experimenting with it. On a grant from the Fund, next year the Alabama Educational Network will start broadcasting basic curricular materials to the majority of the schools of the state; and the Southern Region Education Board proposes a regional network for the same purpose, with some 60 originating studios and more than 160 outlets in school systems and colleges, throughout the 16 states of the southern region.

Meantime, as the unique potentialities of television become increasingly apparent, television is being used more and more imaginatively for instructional purposes. New York University has two such projects in the drawingboard stage.

Because its School of Education has no model school in which teachers-in-training may observe demonstration teaching, some of its faculty are proposing a model classroom with one-way-vision glass walls within a television studio. The master teacher's procedures with his class would be televised through the walls of the classroom and relayed to a series of viewing rooms. In each room would be a critic-teacher who, immediately after the demonstration, would discuss it with the students. This technique might materially improve the quality of demonstration teaching; and should prove economically practical as compared to the cost of operating a demonstration school.

Some of the physics and television faculties of the Washington Square College of New York University are playing with the idea of a television science laboratory. This laboratory would have a bench in the form of a hollow circle, with students stationed on its inner and outer peripheries. The laboratory instructor would be stationed in the center. Two-way audio would enable each student to talk with the instructor. When a student asked for help, a remotely controlled camera traveling a circular track above the bench would move to the student's station, and would transmit a view of his experiment to a viewing screen on the instructor's table as they talked.

In case discussion could not clear up the difficulty, a camera mounted on the instructor's table, connected with a viewing screen mounted at a shallow angle at the front of the student's station, would enable the instructor to demonstrate to the student how to resolve his difficulty.

Fantastic? Perhaps. But the mere fact that such bold thinking is going on presages a tremendous technological revolution in education!

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Washington County Educational Closed-Circuit Television Network, 1956—1957

By WILLIAM C. WARMAN

This paper describes a radio-frequency transmission system used to transmit six simultaneous television channels from studios to 23 schools in Washington County, Md. This TV network is a part of the facilities provided for a five-year national educational experiment to evaluate the use of television as an aid to education.

DURING the summer of 1956, the Washington County Board of Education began a five-year project to determine the effectiveness of the use of television as a teaching medium. This project is a national trial of a county-wide application sponsored by The Fund for The Advancement of Education and the Radio-Electronics-Television Manufacturers Assn. (RETMA).

The television facilities for this project comprise studio facilities, a multichannel closed-circuit network, distribution facilities within the school buildings, and 21-in. TV sets in the TV classrooms. The studio equipment and the facilities within the schools were installed under the supervision of the Engineering Dept. of the school board. This paper will describe the closed-circuit network provided by the Chesapeake and Potomac Telephone Company of Maryland to interconnect the studios with the various schools. The entire network was installed and is maintained by telephone people performing their normal job functions.

The 1956 network provided for three simultaneous TV channels to interconnect five program originating locations with eight schools in Hagerstown, Md., and was 12½ miles in length.* These facilities were expanded this year to serve 23 schools with six simultaneous television channels and a network 33 miles in length. In 1958, it is planned to expand the network to serve all 48 schools in the county with six channels, and the network will then be approximately 130 miles in length. The 1956 network and the two extensions are shown on Fig. 1.

The network is basically a radio-frequency transmission system having sufficient bandwidth to carry six TV channels. The system is comprised of six miniature TV transmitters, a single coaxial line facility equipped with broadband amplifiers, receiving end facilities, and associated equipments.

Video and audio signals are originated from camera and microphone facilities at the six studios located at the Board of

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*W. C. Warman, "Closed-circuit network for educational television," *Trans. AIEE*, Paper No. 57-668, presented at Montreal, Que., June 28, 1957.

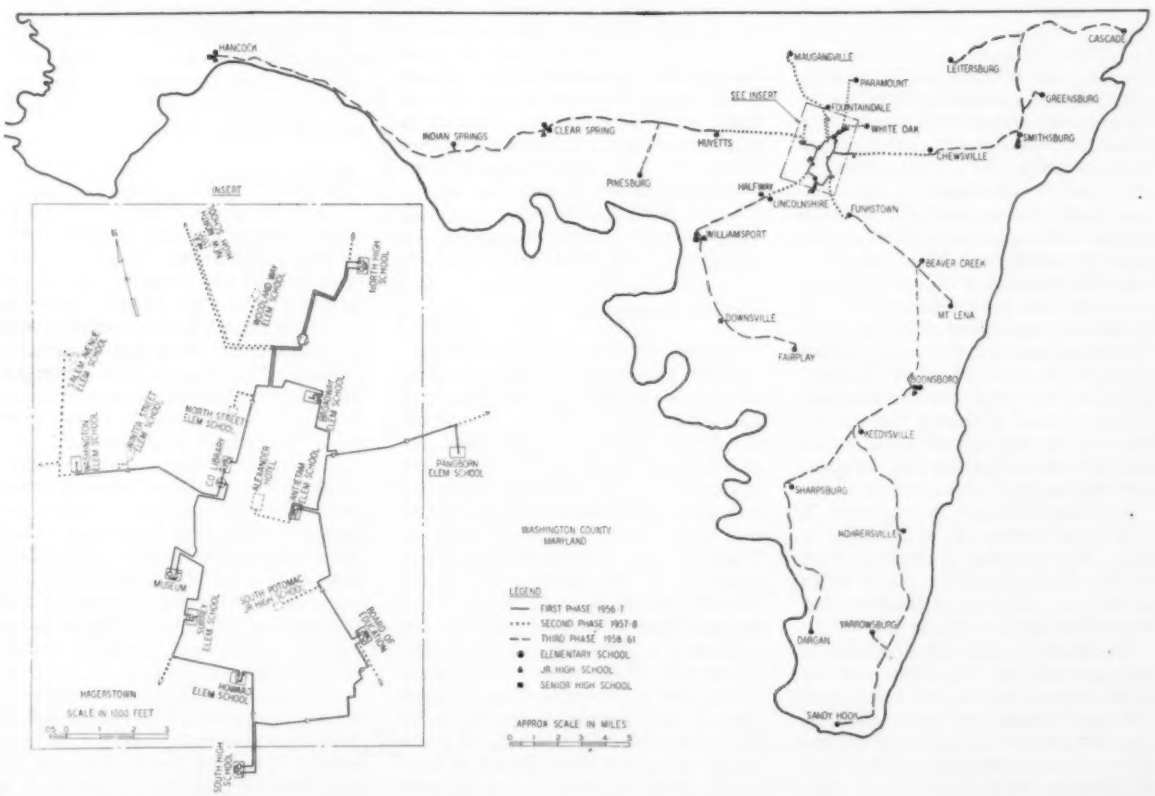

Fig. 1. Washington County Closed-Circuit TV Network.

Fig. 2. Board of Education Transmit Terminal Equipment (during final tests):
left bay, video monitor and receiving-end converters;
2nd bay, Channels 2, 4, 6, 7, 9, 11 transmitters;
3rd bay, transmitting converters, (77-mc) pilot generators, amplifier;
right bay, coaxial relays (behind panel), channel blocking filters, automatic level control panel and amplifiers;
top of bays, transmitter—all Channels 2 to 13 for standby and loudspeaker for order wire

Education building and are fed to each of the six TV transmitters. The radio-frequency carriers of these transmitters operate on the conventional television broadcast frequencies of Channels 2, 4, 6, 7, 9 and 11. Channels 2, 4 and 6 are transmitted over the coaxial network at their normal frequencies in the band between 54 and 88 mc, while Channels 7, 9 and 11 carriers are converted downward into a subchannel band (25 to 51 mc) and are transmitted at line frequencies below Channel 2. Receiving facilities are provided at the individual schools to retranslate the three subchannels back to their normal broadcast frequencies. This permits the use of conventional broadcast receivers which may be tuned to the regular television channels.

A "Round Robin" arrangement is used as an inter-ring in Hagerstown to permit the origination of programs from the Board of Education, North High School, the Library, the Museum and South High School as required.

The Board of Education terminal is equipped with six transmitters and the remote originating locations are equipped with one transmitter each. Blocking filters are provided at the Board of Education to prevent repetitive trips around the inter-ring. When it is desired to originate a program at a remote location, a blocking filter is inserted in the "Round Robin" at the remote location and the filter associated with that channel is switched out at the Board of Education. All schools which are not located on the inter-ring are fed as branches off the "Round Robin." These branches will extend to all schools throughout the county in 1958 as shown on Fig. 1.

Network Description

Transmit Terminals

Each TV transmitter is connected through a channel bandpass filter to a combining network which is connected to the line facilities. In addition, the transmitters of Channels 7, 9 and 11 are connected to transmitting converters and subchannel bandpass filters before connection to the combining network. There are also channel blocking filters connected to the receiving end of the "Round Robin," coaxial relays to switch the individual channel blocking filters in and out of the network and certain testing facilities at the transmit terminal. A 77-mc pilot generator, with its bandpass filter, is also connected to the line facilities at the transmit terminal. The terminal equipment at the Board of Education studios is housed in four bay-type cabinets (Fig. 2).

Line Facilities

The line facilities of the network are comprised of approximately 9 miles of 0.92-in. solid dielectric triaxial cable (this has two insulated concentric shields, designed to enhance the shielding effect), 4 miles of $\frac{1}{2}$-in. aluminum coaxial cable, and 20 miles of $\frac{3}{8}$-in. copper coaxial cable. The use of the three types of cable was dictated by availability. The $\frac{3}{8}$-in. copper coaxial cable will be used for all future extensions. Line amplifiers having a bandwidth of approximately 20–100 mc are inserted in the cable facilities on an average spacing of $\frac{3}{4}$ of a mile. Nine of the amplifiers on the "Round Robin" are located in schools or other municipally owned buildings. Twelve of the amplifiers on the "Round Robin" and all of the amplifiers on the branches are pole-mounted. All amplifiers except those at originating locations are housed in outdoor-type cabinets and operate on 115-v, 60-cycle, a-c power. Voltage regulators are provided for increased stability.

Every third amplifier is equipped with an automatic level control circuit which utilizes the pilot signal as a reference and adjusts for the level changes in the three preceding sections. These changes result from the variation of cable losses with temperature and aging of the vacuum tubes in amplifiers. At the automatic level control amplifier locations there is also a sensing device which sends in an alarm over regular telephone pairs to the Hagerstown Central Office in case of an interruption to the network or a low level signal. A party line order wire interconnects all amplifier locations for alignment and maintenance coordination.

Receiving Terminals

There are three arrangements used to provide the appropriate channels to the schools. The channels generally are utilized as follows: Channels 9 and 11 are allocated to the High Schools; Channels 6 and 7 to the Junior High Schools; and Channels 2 and 4 to the Elementary Schools. This arrangement minimizes the number of receiving converters required. Channels 2, 4 and 6 are available to all of the schools on the network.

To provide for the channels required at the individual types of schools, Channels 9 and 11 receiving converters are placed at all the High Schools and Channel 7 converters at the Junior High Schools. The individual subchannel frequencies of Channels 7, 9 and 11 are separated at the input of the receiving end converters with a filter network having sufficient selectivity to reject the unwanted channels from reaching the receiving converters. The output signals from the converters, which are at their normal broadcast frequencies, are recombined with signals of Channels 2, 4 and 6 and connected to the school build-

ing facilities. At the Elementary Schools, the receiving terminal consists of a tap off the network since Channels 2, 4 and 6 are transmitted on the natural frequencies. The individual feeds to the schools are obtained by either a directive coupling device or dividing network. The coupler has a minimum loss to the line with a large loss to the tap while the dividing network has a nominal loss to the line and the same loss to the tap.

Alignment and Tests

This transmission system utilizes a bandwidth of approximately 25–88 mc, and the amplitude of the signals is equalized "flat" to within ± 1 db over this band. The equalization of the network is accomplished by means of a 4-db positive slope in the gain of the line amplifier and 5- and 10-db slope equalizers. In addition to use of the gain slope in the amplifiers and the slope equalizers, it was necessary to reduce individual peaks or valleys in the amplitude of the signals within the 25–88 mc band with locally designed "mop-up" equalizers.

"Sweeping" techniques were utilized to equalize the system. A sweep generator having a bandwidth of 70 mc and the transmitting terminals of the lowest and highest channels as well as the pilot generator were connected through a combining network to the transmitting end of the network at the Board of Education. The gain-frequency characteristics of the system were viewed on an oscilloscope at the output of each amplifier and the necessary equalizers applied. The transmitter carriers of the two channels and the pilot served as markers on the swept trace on the oscilloscope. An attenuator was connected in series with the line at the test location to provide a means of determining the relative amplitude of the signal trace on the oscilloscope.

The absolute output level of the amplifiers was adjusted by means of a field strength meter measurement of the pilot signal. The system was adjusted so that the minimum video signal at the input to any amplifier was plus 8 dbmv (decibels referred to 1 millivolt across 72 ohms impedance) and the maximum video signal level at the output of any amplifier was plus 42 dbmv. The minimum signal level in the system determines the amount of noise in the picture and the maximum level determines the principal component of interchannel cross modulation. The noise level can be improved by shortening the spacing between amplifiers, at the expense of increasing cross-modulation products. Thus there is a limit to the number of amplifiers that may satisfactorily be operated in tandem. These modulation products may be reduced in part by the use of appropriate filters at both the sending and receiving ends, and in part by careful control of the relative signal levels at the amplifier outputs.

Performance

The 1956 network provided a satisfactory service to the eight schools in Hagerstown. The picture quality was good and there was only a small amount of snow (noise) in the picture. The audio quality was fair and was relatively free of noise. There were two interruptions in the network during the school year, both resulting from physical failures.

Based on the results obtained from the first year of operation several improvements and additions were introduced coincident with the 1957 expansion. These were: (1) improved coaxial cable, (2) 25,000-hour-life tubes in the line amplifiers instead of 6,000-hour tubes previously used, (3) new amplifier cabinets for both the single amplifier and automatic level control equipment (Fig. 3), (4) new automatic level control panels, (5) a transistorized alarm panel, (6) a new type of TV transmitter to improve the audio quality, (7) changed amplifier spacing to improve the signal-to-noise ratio 8 db, (8) new bandpass filters having greater selectivity, and (9) improved alignment procedures employing "sweep" techniques instead of point-by-point signal measurements.

Conclusion

The television network described above provides a satisfactory means for the simultaneous transmission for educational purposes of six video and six audio channels to 23 schools from five origination points. It has grown from three channels serving 8 schools in 1956; and is now planned to be expanded to 49 schools in 1958.

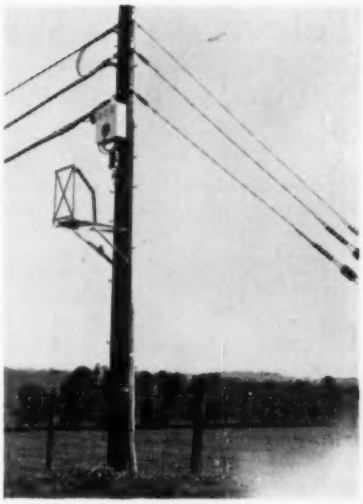

Fig. 3. New type of pole-mounted single line amplifier cabinet.

Acknowledgments

The author wishes to acknowledge the valuable assistance of my co-workers at The American Telephone and Telegraph Company, Bell Telephone Laboratories, Inc., and The Chesapeake and Potomac Telephone Company of Maryland, and to those companies who have supplied the principal items of equipment for this project. These suppliers are: cable, Phelps Dodge Copper Products Corp., Times Wire Mfg. Co., and Western Electric, Inc.; amplifiers, alarm units, amplifier cabinets, converters, equalizers, level control equipment, filters and associated equipments, Spencer-Kennedy Laboratories, Inc.; television transmitters, Kay Electric Co. and Tel-Instrument Corp.; special test equipment, Kay Electric Co., Jerrold Electronics Corp., Conrac, Inc., and Allen B. Dumont Laboratories, Inc.

Television in Washington County Schools, Hagerstown, Maryland

By JOHN R. BRUGGER

Teaching by television has been tested in the elementary and high schools of Washington County, Md. The effectiveness of this method is evaluated and the problems encountered, particularly with respect to equipment and facilities, are described.

ONE OF THE MOST exciting and interesting operations involving education and television is probably the Washington County closed-circuit project. Certainly one of the popular uses of television today is the direct instruction applications to adult groups, college classes, high school, and grade school students. The purpose of the Washington County closed-circuit operation is to determine the effectiveness of this medium in reducing some of the many administrative problems confronting our school systems today. It was with much contemplation and deliberation that a group was formed to cooperate in a five-year project which was to afford an extensive study of the uses television might serve in the area of direct instruction in the elementary, junior high and senior high schools of Washington County, Md. This group included:

Members of industry;
Electronics Industry Assn. (formerly Radio Electronics Television Manufacturers Assn.);
Fund for Advancement of Education;
Joint Council on Educational Television;
The Chesapeake and Potomac Telephone Company of Maryland;
United States Office of Education; and
The Board of Education, Washington County, Hagerstown, Md.

The agreement was proposed and accepted by all participating groups and is administered under the direct control of the Board of Education.

After preliminary details had been worked out by this group of cooperative-minded administrative and business officials, the project began with the opening of the 1956 school term, involving about 6000 students in 12 grades in the Washington County Schools. Three operating studios, 13 studio teachers, three operating channels and some 13 miles of cable joined eight schools in televised direct instruction. Eleven telecasts were transmitted daily over the three Very High Frequency (VHF) channels and 6000 students viewed the telecasts in the various schools included in the closed circuit. Standard TV receivers served the viewing areas. Telecasts usually originated at the location of the three studios which may be referred to as the television center; however, all schools could be served from any one of five locations within the city. In addition to the television center, facilities were included to originate telecasts at North Hagerstown High, South Hagerstown High, the City Library and the County Museum of Fine Arts. Some observations of the first year might be listed by stating that:

(1) The medium lends itself well to a teaching situation whereby the studio teacher can present pertinent information in a logical sequence with much rapidity, taking advantage of the ability of the student's minds to comprehend ideas faster than the word can be spoken.

(2) The students' attention is concentrated in a selected area at close range, contrasted to the frequent awkward situation in conventional classroom arrangements.

(3) During the telecast, the classroom teacher moves about the room observing students' reaction and participation (in taking notes, completing written exercises and in discussions which are incorporated in the telecast).

(4) The studio teachers, by virtue of their new activity, are allowed the full time to develop better lessons, present telecasts and coordinate their work with classroom teachers.

(5) The classroom teachers are relieved of lesson preparation for the telecast and thus are able to devote their efforts more extensively to other administrative classroom work.

(6) Better instruction is indicated through use of television by scores on examinations and growth of learning comparisons.

(7) Emphasis is placed on fitting television to teaching rather than teaching to television.

Equipment

As a result of the many encouraging indications of the benefits which stemmed from use of television during the first year and in keeping with the intent of the five-year project, the Board of Education, with the cooperation of the other agencies associated with the program, expanded the operation during the summer of 1957 to include 14 additional schools and an additional 5,800 sq ft of studio floor space. With the completion of the renovations the following equipment is now in operation:

(1) Five live video studios are equipped with two vidicon cameras each, complete with video switcher, waveform monitors and picture monitors.

(2) One film studio is equipped with two vidicon cameras; one for film presentation is capable of delivering video from film to any one of the five studios or directly to the network, and the second camera supplies test pattern or other information from an easel. These two cameras operate through a video switcher in order that the desired signal can be selected for display in a particular area.

(3) A standard broadcast type synchronizing (sync) generator is installed to supply driving pulses to all video equipment. Pulses are distributed by means of pulse amplifiers enabling each unit of video equipment to operate independently. A second sync generator and a standard sync switching system supply standby service.

(4) Standard audio consoles are installed in each studio controlroom to provide broadcast standard audio signals.

(5) Two-way communications enable personnel of the controlroom to talk to studio personnel and/or cameramen.

(6) Master controlroom facilities accommodate all rack-mounted equipment, such as sync generators, distribution systems, power supplies and other necessary equipments.

(7) Six low-power radio-frequency transmitters operate at VHF TV Channels 2, 4, 6, 7, 9 and 11, together with the associated equipment relevant to distribution of the video-audio signals, originated by the respective studios.

(8) Radio-frequency amplifiers, equalizers, automatic level control amplifiers and associated distribution equipment supply the signal to the 14 additional schools.

Since vidicon equipment is used exclusively in this operation, discussion will be limited to such applications. It is not the intent of this discussion to compare vidicon equipment with other types of video equipment. In interest of economy and ease of maintenance, it is suggested that the vidicon offers many merits for use in closed-circuit operation in direct instruction applications. The Washington County closed-circuit operation has followed, for the most part, the standards and techniques usually associated with commercial broadcast prac-

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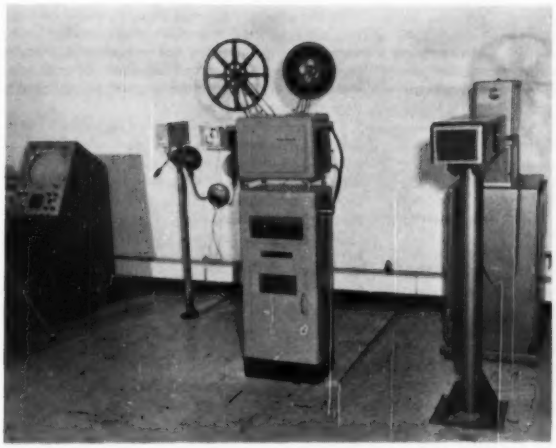


Fig. 1. The projection room.

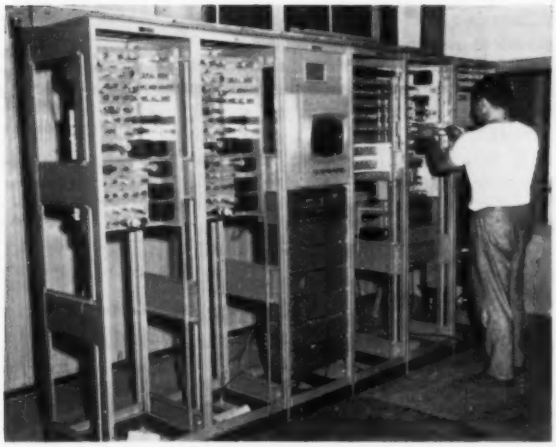


Fig. 2. Installation of equipment in control room.

tices. These practices seem mandatory in view of the fact that the service rendered is transmitted over an extended area, and the minimum standards familiar to the state of the art must be maintained.

Telecasts transmitted from the television center are viewed by about 12,000 students distributed in the 23 schools currently connected by the circuit. Further, the program, as originally planned, will be extended during the summer of 1958 to include a total of 48 schools in Washington County. In order to assure the desired results, many stringent demands will have to be met. Close control will necessarily have to be kept on percentage modulation, transmitter signal strengths, cable and amplifier characteristics as well as other signal qualities which must be maintained.

Another consideration which should not be overlooked is the fact that students viewing in schools have already become acquainted with commercial broadcast television, and whether educators wish to accept the technical quality of such operations or not, students are well conditioned to a transmission quality which has perhaps inadvertently set the standard. Set performance and comfort of the viewer, ease of set adjustment and apparent balance of cameras and channels are other criteria which must be evaluated. Various display methods offer additional consideration. Large-screen projectors may well serve larger viewing groups.

Procedure

Early in the planning of the operation, engineering considerations were discussed. It was decided that the staff of the Board of Education of Washington County would develop studio areas, and install the necessary equipment for such an operation (which was to be supplied by members of industry and the Electronics Industry Association). The agreement was based on the following considerations:

(1) The Board of Education would originate the video and audio signals according to "Good Engineering Practices" as recommended by the National Association of Radio Television Broadcasters.

(2) The Chesapeake and Potomac Telephone Company would supply low-power transmitters and distribute the modulated radio-frequency signals to the schools involved in the program.

(3) The modulated radio-frequencies would be available in the schools at the standard TV frequencies of Channels 2, 4, 6, 7, 9 and 11.

(4) The Board of Education would distribute the modulated radio-frequencies as desired in the various school buildings.

(5) Students would view the telecasts on standard TV receivers and/or large screen projection systems.

(6) Display devices would be located conveniently to provide optimum use of the equipment, and light sources would be controlled.

(7) Telecasts would be transmitted to the various classroom areas through the closed circuit using combinations of up to six simultaneous transmissions.

Having reviewed the elements involved, broadcast studio production techniques are generally used in lesson telecasts. The studio lighting simulates, in many respects, the procedures observed in broadcast studios. It is the profound intent of the staff of the Board of Education to avoid any manipulations or limitations, accorded because of television, which may detract from the teaching effort. Further, it is a matter of policy that the studio staff adapt television to teaching rather than the reverse. Since many of the opportunities television offers in new presentation methods are still being discovered, it seems that much of the effectiveness of television in direct instruction applications is yet to be experienced. Telecasts usually consume not more than one half of the regular class meeting time. The classroom teacher (a certificated teacher) uses approximately one half of the class meeting time to pursue the subject matter, answer individual questions and continue the discussion.

Conclusions

Television is one of the newest of communication devices. The applications this medium offers school administrators are many and varied. It serves as a convenient way to communicate with subordinates, to expedite teacher training programs and to acquaint vast student groups with gifted scholars or talented artists. Whether its use in direct instruction be for specialized groups or general student bodies, the following attributes are noted:

(1) The students' interest can be maintained during telecasts. Often interest is even increased by interruption of the telecast to allow short classroom discussions.

(2) More subject material can be presented than in the normal classroom situation by virtue of the TV facility, lesson preparation and planning.

(3) The studio teacher is able to involve student participation in the telecast by use of prepared written materials, note taking, and other "seat" work.

(4) Students have the benefit of a type of dual instruction (two teachers rather than one) from the studio and classroom teacher.

(5) Television offers a convenient method of presenting film and many of the awkward mechanical details of the ordinary projection of film in the classroom can be avoided.

(6) Film inserts may be used in conjunction with a lesson or entire subject

matters can be presented to large groups in various areas simultaneously.

(7) Experiences to date indicate more film will be used in closed-circuit operations than in normal conventional school systems.

(8) Better use can be made of film in closed-circuit operations as a result of the ease of presenting the film. Savings (of a kind) are indicated by less need for multiple projection systems and operating personnel.

(9) Television serves a real purpose in communicating education in a forceful, effective manner and is destined to take a place among the printed textbooks, films, charts, graphs and other teaching devices; each of which has become an integral part of the teaching-learning process.

Discussion

Robert White (National Broadcasting Co.): Have you made it possible for students or teachers at remote schools to question the teacher that has been giving a lesson?

Mr. Brugger: We have no standard two-way talk system as has been suggested by some operations. We feel that students have an opportunity with classroom teachers to have those questions satisfied. Our operation is based on a studio teacher and a classroom teacher, both certificated. The studio teacher might be referred to as a "specialized" teacher; the classroom teacher may not have specialized in that particular field. The students can ask the classroom teacher questions and, if the questions warrant it, the classroom teacher does contact the studio teacher. This has a dual effect — the student who raises the question feels proud because he was able, perhaps, to hit upon a principle not included in the lesson, and it challenges the others to do likewise, all trying to determine if a good point might have been missed in the lesson.

Mr. White: I noted that there were five receivers in one of the classrooms, which is quite an investment. In the long run, might not large-size screen projection equipment, or medium-sized projection equipment, be more effective and perhaps as economical?

Mr. Brugger: I think that's a question which bears more investigation than we have had to date. Our classroom situations are these:

The two high schools have six or eight viewing rooms, each equipped with approximately 80 chairs. The classrooms total about 30 in each of the schools. I think four sets is a standard complement for a viewing area which will accommodate approximately 60 students.

In the grade schools we literally have every classroom wired and equipped with one set. We would prefer to have two sets in each of these classrooms. In the lower grades there are from 20 to as high as 40 students in one room with one set. It seems to me that the cost that you mention is considerable, yet two sets is not too much for that large a student body and there is a lot of protection in the second set in case of a set failure.

We're using table models for the most part with side-mounted speakers. These are quite inexpensive. For such an area, I would recommend the standard receiver with the front-mounted speaker for better distribution of sound. We're using standard VHF 21-inch receivers and it seems that, if we program properly, we can serve a 20-foot radius, 60-degree angle of viewing by students, quite well.

We do have two large-screen projection units and we're using them in areas where we have as high as 200 students congregated. Since we are just on the threshold of that application, an evaluation cannot be made now.

Pierre Mertz (*Bell Telephone Laboratories*): What is the portion of any one student's time devoted to receiving television instruction as compared with conventional instruction?

Mr. Brugger: We operate on a schedule of approximately 50% of the class time being devoted to television for each subject. In high school we are offering General Science in 9th grade; 10th, Geometry; 11th grade, U.S. History; two sections of 12th Grade English. The class periods in the high school run about 60 minutes, of which about 25 to 30 minutes are for the telecast delivery. The balance of the time is at the discretion of the teacher who pursues the discussion further, answers questions, and takes care of any further development in the subject matter.

The students seldom view more than one lesson a day, except in the elementary areas where they may receive on a Monday-through-Friday basis, a social study or arithmetic for example, and on a two-day sequence, receive art on Tuesday and Thursday, or in some areas they might have music on Monday, Wednesday and Friday along with a basic subject. Two is the limit. A daily total of approximately 60 minutes viewing per student is our practice.

How far one might go in this direction is a good question: I think the educators should decide how the time might be divided. Conceivably, the student could receive instruction by television half the day on our plan. It's our opinion that the classroom teacher is as important as the studio teacher. There is no differential in pay, and it seems that the real crux of the instruction still rests in the hands of the classroom teacher.

Anon: Could you describe the nature of the coordination between the classroom teacher and the television teacher?

Mr. Brugger: During the summer of '56, and also this past summer, we had a six weeks' workshop. This workshop included the classroom teachers as well as the studio teachers. They developed their lesson plans for the entire year. In that way they could agree on the time, emphasis, and various aspects of the educational process; then as the school year progresses the studio teacher prepares, a month in advance, work that he plans to cover and distributes it to the classroom teachers.

Periodically, monthly or more often, the teachers of a given subject get together. They decide whether they have gone too fast, or omitted anything; whether they're using the best procedure. The studio teacher has to think not only about the vast audience of students but also about his colleagues who are observant of the subject material presented. So, I believe, as a by-product, we have found that the studio teacher is under a new strain, and is more conscious than ever of presenting good lessons.

Fred Anderegg (*University of Michigan*): Do you plan to do any kinescope recording, either for re-broadcast the following year or for showing in schools which are not linked up with your network?

Mr. Brugger: We want to do kinescope recordings but have nothing in operation now. Kine recordings would be useful in training teachers, as well as for repeated instruction of students.

This leads to the matter of film use. I think that film has a place in education but its value is hard to measure. I want, however, to re-emphasize the fact that there's nothing better than spontaneity — if it's planned spontaneity. We seldom have adequate time to rehearse lessons; however, we want the teacher to plan his work so that he can present it in good form and order, and keep it as spontaneous as possible. We use the same people on the particular telecasts at all times: for example, a teacher always works with the same crew. I don't need to emphasize the good that comes out of a team working together.

We believe, too, that the studio teacher is the one that really has the message and he should be producer as well as teacher. So the person who does the production must learn to think like the teacher if he's not a teacher, and work so closely with the subject matter that he is actually executing the directions of the teacher. Rather than the producer directing the teacher, the teacher is directing the producer.

Charles O. Probst (*Cinefonics*): Could you give us further information on your use of film — the proportion of film to live telecasts, and whether films are used as an entity or whether individual sequences might be lifted from a film to fit into a teacher's live presentation?

Mr. Brugger: We have a unique setup; as you noted, one film chain is available to any studio or directly to the network. One film chain can't handle the traffic that we really have, because each teacher in each studio might require film at a given time. These studios you saw often operate simultaneously, so one film chain doesn't give us an adequate opportunity to use as much film as we'd like.

Last year we had few facilities and less capacity for running film so we used films far less. We are building a film library. We are inserting film clips, 1 minute, 3 minutes, 5 minutes or 15 to 30 minute continuous programming of film — we are trying to set up a system whereby we will have literally a constant flow of film program to the entire school system. As a matter of fact, in our planning you will see that Channel 2, which goes to all areas, is reserved for film use exclusively.

Several things can be said in addition to that but, basically, we like to think in terms of having the film going at all times, besides the occasional use by the teachers in their programs. We are hoping for a second film chain. We have standard multiplexers which you probably noticed. We use slides and have a basic 16mm film system.

Lee Furman (*Video Pictures*): Can you tell us what conflicts in interpretation there may be between a classroom teacher and the television teacher?

Mr. Brugger: We have a "coordinator of instruction" who is a "core" man. He is drawn from the ranks and has had years of experience in the classroom, in school administration, as a principal or in similar administrative positions. It is his obligation to work closely with the studio teachers and the classroom teachers, to make certain that they have included in their lessons what is basically required.

We have another man who studies curriculum. I think one of the reasons why Hagerstown was chosen for this experiment was that we are interested in, and have in progress, a broad curriculum development program. This man spends all of his time studying and reviewing the curriculum, checking it to see if it's up to date, if there are new books that should be used, whether the textbook is suitable, etc.

So, we have two people observing subject matter very carefully; and it's imperative that the classroom teacher and the studio teacher work together on what is being taught. Certainly the classroom teacher is still a very important part of this operation and he is not intended to serve as a secondary to the studio teacher.

We have had no real conflicts to date. Of course, I'm not as close to the teachers as I would like to be, and maybe there are more conflicts there than I know. Other educators have mentioned the fact that they expect to pay a premium for the studio teacher. This is not our policy. Our opinion is that the classroom teacher is as important, perhaps more important, than is the studio teacher. The classroom teachers are the ones working directly with the students. The studio teacher merely presents material; the classroom teacher still moulds the personality, develops and stimulates students' thinking and is a very important part of the teaching process.

Herbert Barnett (*Session Chairman*): I'm not surprised at the interest in this subject, because closed-circuit television has a great promise; but in deference to the speakers to follow, we must terminate this discussion.

Bulk Magnetic Film Demagnetizing Practices

By LORIN D. GRIGNON
and A. P. GREEN

This paper is a very brief summary of practices used in the several Hollywood studios. Significant factors which have been observed and problems which are encountered are mentioned.

THE FOLLOWING notes on demagnetizing practices and devices in Hollywood motion-picture studios were compiled as a current status report in this field. By bulk demagnetizing is meant the demagnetizing of magnetic film or tape in rolls. The practice of demagnetizing with a magnetic head immediately before recording is not desirable in motion-picture practice, where the film on which records are made must be as quiet as is feasible, without the added complexity and hazard of demagnetizing heads on recorders.

There are two general types of bulk demagnetizers differing only in that one uses iron-core and the other air-core coils. The film to be demagnetized is passed through the coil, or in and out of it on one side; or it is passed between the fields of two sets of coils with one or more on each side of the film roll. In all cases, the film roll is rotated as it moves in and out of the field, or as the field is varied by increasing and decreasing the current through the coil or coils by a variable autotransformer.

The iron-core types have the potential disadvantage that the more concentrated field resulting from the iron-core may result in nonuniform demagnetization if the rate of change of film movement over the core is great. Nonuniformity of appreciable magnitude may become apparent not only as actual noise, but as the cause of some quality change. A disadvantage of the air-core is the extensive external field and low values of transverse flux.

A maximum rate-of-change of field intensity relative to any magnetic particle of the moving film must not be exceeded if the film is not to retain a residual record of the demagnetizing current. This has been estimated, rather empirically, at 10% per half-cycle, but all actual devices change at a much lower rate than this. As a matter of fact, great speed of movement is usually not necessary because demagnetizing in a studio is not a large or expensive operation.

Presented on October 10, 1956, at the Society's Convention at Los Angeles, by Lorin D. Grignon (who read the paper), 20th Century-Fox Film Corp., Beverly Hills, Calif., and A. P. Green, Warner Bros., Burbank, Calif.
(This paper was received on May 15, 1957.)

Magnetic film is capable of producing a signal-to-noise ratio of 65–70 db below a signal of 3% harmonic distortion. The film will, of course, record signals above what is customarily considered maximum level, perhaps 10 to 20 db higher, and demagnetizing must be able to remove such high-level signals completely. The devices in use in most studios will do this. In many cases the film will be on cores. In some cases it may be on reels or in aluminum cans, as in the case of unexposed striped photomagnetic film, which cannot be exposed to light as it is demagnetized.

In general, theory indicates that demagnetizing flux is most effective when its direction is that of the recording. For example, recordings made longitudinally, in the direction of film travel, establish minute magnets having north and south poles similarly arranged; effective demagnetization is then accomplished by flux in the same direction. For this reason, nearly all demagnetizing devices arrange the film position with regard to the coils so that the strongest flux path corresponds in direction to that of the recording; in any case some longitudinal component must be present.

Sound records in the center of the film, as in multitrack recording on 35mm film, are exposed to lower flux densities because they are further removed from the source of flux when coils are used at the sides. When the film roll is passed through an air coil, this condition does not hold to the same degree. The idea persists that inside tracks are substantially shielded by the surrounding magnetic material, but this is a secondary effect since the permeability of oxide is only about 3.

It has been found that transverse fields, as well as longitudinal, provide more complete demagnetization, particularly on multitrack 35mm film. This may be explained as follows: The recorded flux at the track edges, known as fringing, has both transverse and longitudinal components and when, as is often the case, the reproduce heads have the same width as record heads, this random stray magnetization must also be removed. Additionally, transverse fields are generally uniform throughout the film width and are, therefore, helpful as a "clean-up" where inside tracks are used. Iron-core demagnetizers having only longitudinal flux have been built and give excellent results on film striped near the edges, but they are inadequate for multitrack full-coat 35mm. film. Conversely, demagnetizers having principally transverse fields are not usually satisfactory for striped film.

A very diffuse random field, with substantial components in the transverse and longitudinal directions, must be used, or a similar result provided for by suitable orientation of the product or by otherwise changing the direction of the field. In all cases, the magnetic material should be exposed to maximum fields while being rotated at least one revolution. Experience and test have indicated that the minimum flux density requirement is about 300–400 gauss and that double this is a practical value.

Figure 1 shows generalized flux paths

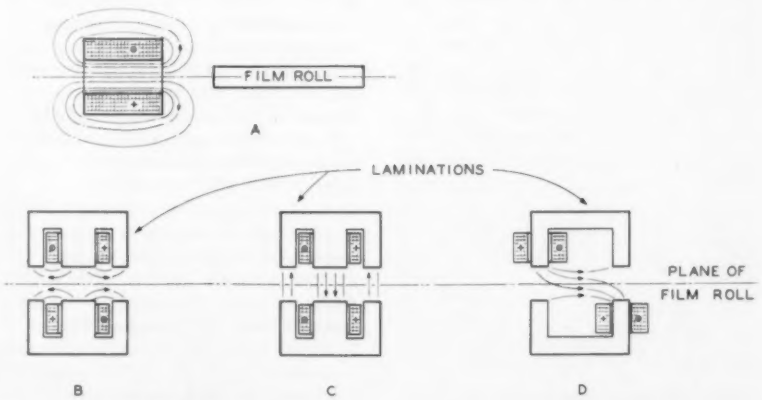


Fig. 1. Generalized flux paths.

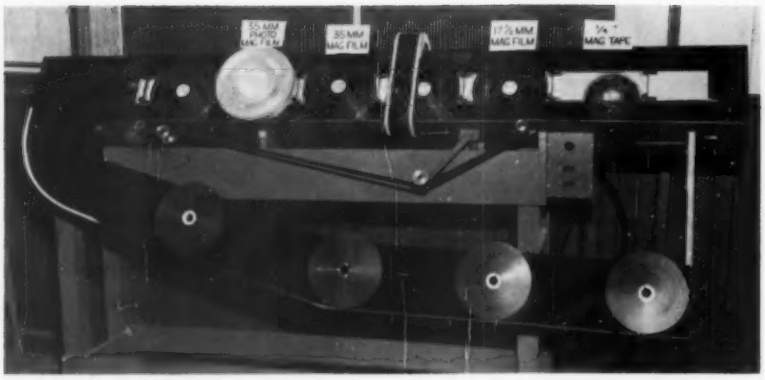


Fig. 2. Metro-Goldwyn-Mayer continuous machine.

for various arrangements now in use in the devices to be described. The air-core coil in A has a flux volume distribution which is essentially toroidal, although only one cross section is shown. The E-type lamination iron-core coils may have flux from tip to tongue as shown in B or transverse as in C when suitably poled with coils placed opposite each other. In D is shown another possibility using U-shaped laminations, opposed to each other, poled and located so that the flux has both longitudinal and transverse components.

In the case of one 70mm device, which will handle 2000-ft rolls, and in which two stacked 35mm rolls can be demagnetized simultaneously, it has been found desirable to pass them through twice, with the rolls stacked in opposite manner during the second pass.

Taken in alphabetical order, specific studios at present use the following equipments.

Columbia has two devices, one in their printing room and one for production recording. The field is produced by two coils facing each other on opposite sides of the roll of film which is passed between them, while rotating, by a conveyor belt. The coils are connected aiding during part of the demagnetizing cycle, and opposed during part, thus varying the direction of the demagnetizing field through the roll of film. The complete device is about the size of a desk. It draws about 25 amp (60-cycle a-c) with condenser power factor correction. It will demagnetize the center track of a 3-track 35mm film down to virgin film noise from 10 db above 2.5% harmonic level.

Disney uses a commercial-type device, which they modified to operate semi-automatically. It handles one roll at a time, rotates the film, brings current up and down with a Variac, all automatically started with a push-button. Film is placed on and taken off manually.

The principal design feature of the Samuel Goldwyn Studio magnetic film eraser lies in providing an extremely strong magnetic field for just sufficient duration to effect a complete and uniform erasure of the film. A short duty cycle has one outstanding advantage in keeping the coil heating to a minimum. It also permits more rapid operation and the use of smaller components. Since the eraser is fully automatic, no skill is required on the part of the operator to assure complete erasure without leaving "thumps."

The eraser is of the open air coil type in which a roll of film, either on or off a reel, is placed upon the turntable located within a $2\frac{1}{2}$ by 12-in. window of a 250 turn coil. By depressing the "start" button a circuit breaker is closed, immediately subjecting the coil to a current of 40 amp and at the same time activating a gear head motor belted to the turntable rotating at 8 rpm.

After 120° of rotation, requiring approximately $2\frac{1}{2}$ sec, a Powerstat control is engaged and the current gradually reduced to zero over the next $7\frac{1}{2}$ sec. At this point the film is completely erased and may be removed. The motor is then automatically reversed by a limit switch and the Powerstat returned to its original full voltage position. During this return cycle the circuit to the coil remains open. A second adjustable limit switch on the Powerstat is used to stop its rotation at any predetermined voltage. In this manner the maximum coil current may be adjusted to any value up to 50 amp. The total time for a complete cycle is 20 sec which may be reduced to a minimum of 12 to 15 sec if found desirable.

Three factors were found to be of prime importance during the development of this eraser, namely:

1. A quarter turn of the roll of film under full coil current is sufficient for a complete and uniform erasure.
2. The turntable rotation must be kept smooth and slow to avoid the recording of low frequency "thumps."
3. A coil current of 40 amp was arrived at empirically for complete erasure of present-day recording stocks.

It is stated that the eraser may be operated continuously without excessive heating. Flux density is estimated at 250–350 gauss.

M-G-M has four devices. Two of these handle one roll of 1000 ft, or less, at a time, moving the rotating roll out of the field automatically, after rotating it in the field of a single coil for several revolutions. A third machine of the same type, for 70mm film rolls up to 1500 to 2000 ft in size, will also handle two 35mm rolls of 1500 to 2000 ft at a time, stacked one above the other. These units subject the film to a collapsing field of 10 to 15 gauss when the current is turned off, because the film is within 3 ft of the coil; although there has been no gross evidence of difficulty due to this condition, it is not known for certain to what extent this is disadvantageous.

The fourth is a semicontinuous-operation device which passes rolls of 1000 ft or less, one after the other, through a coil, rotating them as they go (Fig. 2). In this machine the linear motion of the rolls is produced by a belt, with partitions, moving at a rate of $10\frac{1}{2}$ ft/min. The rotation of the rolls is produced by another belt on which the rolls rest as they are moved linearly. This belt moves in a direction opposite to the linear movement, at a speed of 113 ft/min. The rolls make about five revolutions during the time they actually pass through the coil window, each revolution requiring about $1\frac{1}{4}$ sec.

The whole cycle of operation of this machine, for one roll, from putting it on to taking it off, requires about 35 sec. Rolls go through about every 7 sec. The coil in this device has 341 turns of #10 wire, drawing 32 amp from a 60-cycle 220-v line, but the line load is reduced by 184 μf of power-factor-correcting capacitors, to about 12 amp. With more capacitors the line load could be reduced to perhaps 5 amp. The larger coil (for 70mm) draws 42 amp at 220 v without power-factor correction. Ampere turns are about 10,500; field intensity is 500 to 600 gauss longitudinal and 100 to 150 gauss transverse component. The coil gets hot with continued use and usually about 10 to 20 rolls are demagnetized at one time. The machine can, however, handle 50 rolls at a time without becoming impractically hot. A fan could be added if necessary.

Paramount uses, at present, a commercial device, but is contemplating one similar to that of another studio.

RKO, at present, uses a commercial device. They experimented, using oscillatory discharge of condensers as a source of current, but encountered switching problems incident to the high voltage and current involved in the coil. They dropped these experiments and

Fig. 3. Twentieth Century-Fox Film Corp. machine, Model III.

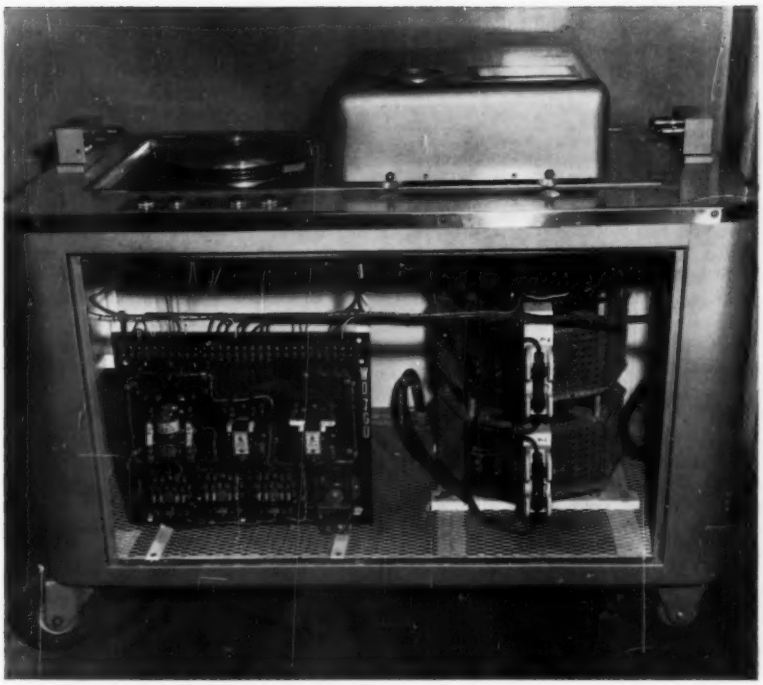


Fig. 4. Warner Bros. Picture Corp. machine.

might at a later time adopt the design of some device in use elsewhere.

Twentieth Century-Fox Film Corp. has three types of demagnetizers, all using iron-core coils. In one, suitable only for multitrack 35mm film, single rolls of 1000 ft or less are located on a horizontal motor-driven platform which passes the roll between two coils, one below and one above the roll. The coil stacks cover a diameter and are not directly opposite, the displacement being $3\frac{1}{2}$ in. The winding of each coil is on one leg of a U-shaped lamination. Coil polarity is arranged for transverse flux, but, by virtue of the relative coil displacement, there is a longitudinal component of slightly lesser magnitude (D, in Fig. 1). At the end of travel in one direction, the platform stops, the roll is rotated manually 90° and the platform motion, in the reverse direction, is initiated. Upon return to the starting point, the platform stops and the roll is removed. The flux density is 200 to 600 gauss, depending upon direction and position, at 10 amp at 220 v, using 650 μf of power-factor correction. The coils arrive at an excessive temperature after demagnetization of 10 rolls; no supplementary cooling is used. The time to do one roll is about 20 sec.

The second kind of machine was designed for somewhat intermittent duty to accommodate only 2000-ft aluminum reels with striped release film. The reel is inserted vertically into a slot and rides upon two rubber-tired rollers. Disposed on each side of the reel are two iron-core coils, each pair on a side being directly opposite the other pair. Two coils are used on each side to fully cover the radius without excessive core stacking. Further, the coils on one side are not arranged on a diameter; the angular displacement about the reel center is chosen so as to prevent repetitive effects as the reel is rotated.

Once the machine is loaded, the start button is operated which causes the reel to be rotated by a motor, through the rollers, and the coil voltage is increased from zero by a motor-driven Superior Powerstat until, 28 sec later, 115% of line voltage is reached. By means of delay relays the coil voltage is held at maximum for 10 sec during which time the roll rotates 2.1 revolutions. Following the 10-sec soak, the Powerstat is driven downwards decreasing coil voltage until zero is attained, whereupon the reel rotation is stopped and the reel removed. The complete cycle takes 64 to 66 sec. In the light of new experience, this period could be shortened substantially.

The coils on each side are connected in series across a 220-v 60-cycle/sec line and opposing coils are connected so that the flux in the film is longitudinal. Note that the coils must be installed so that the core stack corresponds to the reel radius. Physically, the coils are windings on standard E-laminations. The core ends are about $\frac{1}{8}$ in. from the film sides, being separated from the reel on each side by a 0.025-in. layer of glass-fiber plastic applied by pressure and heat to the Duralumin plates forming the reel slot. The glass plastic serves as an excellent nonmagnetic wearing surface.

The flux density at the center of the slot is about 400 gauss. At the stripe positions, the density is about 500 gauss. Line current, without power-factor correction, is 30 amp. Since the reel is driven by its perimeter, good reels should be used so that no very low frequency residual magnetism is developed by large changes from uniform rotation. For the same reason, the rubber-tired drive rollers should be ground to achieve a surface free from bumps and hollows. The important factor in this regard is the circumferential speed and usually the low-frequency, low-level residual noise will be noticed first on the outer layers of film with the defect decreasing toward the inner layers. For example, the first prototype of this device used a reel rotational speed of 17 rpm which resulted in noise in the outer layers. As this speed was reduced to 12.8 rpm, the noise disappeared to a value below audibility.

The line remains connected to the Powerstat at all times and the Powerstat and reel motors are controlled by suitable relays and limit switches on the Powerstat. Small transient suppression capacitors are connected across each motor winding to remove small collapsing fields in the film region when de-energizing these motors. Capacitor-run motors are used in both services to eliminate starting contact troubles and, also, to provide rapid trouble-free reversing of the Powerstat motor.

Figure 3 shows a machine of the same general construction as that described above. This latest machine provides for reel, or roll, diameters from 9 in. to 15 in. Since the reel or roll centers must always be in the same location with respect to the coils, the rubber-tired rollers are on pivoted arms whose positions are simultaneously varied by a crank and two worm-gear sets of right-handed and left-handed types. Each roller shaft is driven by a small timing belt from the shaft pulley to a double pulley on the center of the arm rotation. Each double pulley is driven by a common timing belt from the reel motor. By this drive means, idler and compensating pulleys are avoided. Substantial shocks on the roller shafts from dropping reels into the slot are absorbed by permitting the worms of the worm-gear sets to slide on their shafts against a strong spring. The roller speed is 84 rpm.

The control circuits are arranged so that the same cycle as described for the less versatile model can be used or, by choice of switch position, the cycle is repeated once with directly opposite coils poled to produce transverse flux. At the end of the first or second cycle, as selected, the reel rotation is stopped and the reel, or roll, removed.

The flux density in this latest device is 700 gauss at reel center with a longitudinal direction. At the position of stripes such as release film, the density is 900 gauss and the transverse flux density is 830 gauss. The line current is 48 amp at 220 v 60 cycles/sec, without power-factor correction. With 200 μf of capacitors, the line current reduces to 30 amp. Since the coils will overheat to destruction if full voltage is applied for an extended period due to control-circuit failure, thermostatic cutouts are supplied to disconnect a line circuit-breaker.

This machine will demagnetize striped or multitrack fully coated 35mm film completely even though the recording is made to virtual saturation. The single demagnetizing cycle is used for striped film and the double cycle for multitrack full-coated material. Narrow films or tape may also be demagnetized by using split reels with fillers, or by many other means. The floor space required for the last two described machines is 18 by 24 in.

Universal-International uses a commercial device, which they modified with a motor and a mercury switch and Variac to turn the device on and off and to vary the current up and down automatically.

Warner Bros. uses an automatic bulk magnetic film demagnetizer incorporating six iron-core coils (Fig. 4). The roll of film to be demagnetized is supported on a horizontal table that is rotated continuously during the demagnetizing cycle at a uniform rate of approximately 3 rpm. The six erasing coils are arranged physically in two groups of three. One group is located below the film in the reel well and the other group is located correspondingly in the movable carriage unit above the film. The coil assembly in the upper unit is adjustable vertically. As aligned, the upper coils give adequate clearance to a standard 2000-ft reel. The eraser is designed to demagnetize rolls of 35mm magnetic film on nonmagnetic reels or cores. The demagnetizing area extends from a 2-in. diameter to a 15-in. diameter. Thus a full standard 2000-ft reel of film can be erased. The eraser as aligned will erase the following:

(1) Any roll of 35mm or 17½mm magnetic film on or off a reel (nonmagnetic) up to and including the standard 2000-ft reel.

(2) Any roll of ¼-in. magnetic tape on or off a reel (nonmagnetic) up to 15 in. in diameter.

The coils used in the demagnetizer were designed for continuous-duty operation. Each coil takes 11 amp at 115 v, a-c, 60 cycles. The three lower coils are connected in parallel, and the three upper coils are connected in parallel. Each group is supplied power from one side of a 220-v, a-c line to the neutral through a dual unit, motor-driven Superior Powerstat. The total maximum power required by the eraser is approximately 33 amp at 220 v, a-c. No power-factor compensation has been employed in the unit.

The complete demagnetizing cycle requires 94 sec followed by an 18-sec reset period during which time the operator is removing the erased roll and loading a new roll. During the first 20 sec of the erasing cycle, the voltage is at maximum and the upper and lower coil groups have similar magnetic polarity and thus the primary flux path is longitudinal to the soundtracks. Thirty-six seconds are then required for the Powerstat to reduce the field to zero, to reverse the polarity of the lower coil group and to raise the voltage to maximum again. Then 20 sec are employed with the voltage at maximum and the upper and lower coil groups with opposite magnetic polarity and thus the primary flux path is transverse to the soundtracks. Eighteen seconds are required to reduce the voltage to zero which ends the demagnetizing cycle.

Using a Dyna-Labs Model D-79 Gaussmeter, the longitudinal flux measures approximately 550 gauss and the transverse flux approximately 800 gauss midway between the upper and lower coil assemblies. Any normal magnetic film or tape erased in this demagnetizer will have all prior magnetic pattern removed and will exhibit a signal-to-noise ratio of approximately 70 db. Figure 4 shows a view of the demagnetizer with the upper coil assembly rolled back to expose the film on the turntable. The front door has been removed from the cabinet to expose the interior components.

Conclusion

By now, it is evident that individual engineering effort has produced a variety of devices which to all intents are performing satisfactorily. It must be agreed that there are yet factors involved in the process of demagnetizing magnetic film which have not been thoroughly explored and because of this we do not have a clear, concise design procedure. The choice of type of device to be used is manifestly intimately dependent upon the requirements of the application.

In the preparation of this material, the assistance of each of the Studios mentioned was necessary and freely given. The authors also wish to acknowledge the initial help of Kenneth Lambert, formerly with M-G-M.

Discussion

J. Kenneth Lewis (Dept. of Defense, Washington, D.C.): Considering the use, after a period of storage, of large quantities of material which has been erased by any one of the processes which you have described, has there been any assessment of a change in the background, which might indicate that the material has a memory which shows up from storage?

Mr. Grignon: We have not encountered this, at least not in any serious way, at 20th Century-Fox. I have heard that some of these materials do have bad memory conditions, if we want to call it that.

Al Green (Warner Bros.): We have made tests in this regard; in fact, the studies made on our eraser were based upon the degree of demagnetization and then sensitization by the application of bias. We studied this action with variable bias conditions, that is, as though you were recording in the absence of signal, and we varied the bias to see if it had any effect. Specific tests have been made up to as much as 30 days' storage both in the action of resensitizing the film immediately following erasure and of not resensitizing it until 30 days had passed and then resensitizing the film and reviewing it. We have found that with our method it was total erasure, you might say permanent erasure, with no apparent memory. That is, we can obtain and retain, over our 30-day test, approximately a 70-db signal-to-noise ratio both with regard to residual pre-magnetization and noise. This 70 db is relative to a 3% distortion, 100% modulation level on the film.

Mr. Grignon: One other point, not made in the paper, is that some users may not be involved in requiring high signal-to-noise ratios and as a consequence would question the need of such devices as we have described.

But there's another feature about these devices which is a little bit concealed. This is the point that you always do the same job the same way because of the automatic operation. You are not subject to the human errors of a man removing a roll of film too rapidly from a hand-type operated degausser. If you push the operator to do a few extra reels, he's apt to remove them too rapidly and leave a residual signal. So, if for no other reason, the studios have built these devices, and made them automatic, to eliminate the human element so that the product is always treated in the same way. It would be of interest if Mr. Green would describe the method by which Warner Bros. test for residual noise; this is a very critical test.

Mr. Green: The tests that we undertook with regard to both the air core and iron core coils were prompted by the higher speeds of some of

the newer, wider motion-picture film processes that are now in use. We took standard recordings, degaussing them by various means. We test recorded as high as approximately 20 db over the normal release 100% recording level on the film; and also tested what you'd call virgin film, film that was supposed to be pure. Our procedure fundamentally was to run the film under numerous over-speed reproduction conditions. We made extensive tests at anywhere from two times normal speed up to 16 times normal speed of reproduction, and we monitored the film through selective filters. You can't measure some things when you're talking about sub-audible or residual noise of recording on film when you're considering 70 db down; it has to be interpreted by listening and in doing this we put selective filters in our reproduction system and listened to it over this range of speeds all the way from 180 ft/min up to almost 1000 ft/min, selecting bands out of the spectrum. Of course, when you say sub-audible you are interested then in the low components which would not be audible at normal speed, but when you raise the speed you find you have a residual pattern on the film which is very undesirable. We haven't finished all of our work, but we hope to publish later some of our findings and to clarify some of the effects that are produced purely by sub-audible energy.

Erasing Magnetic Film for Noise-Free Splices

By CARL SHIPMAN
and CARL HITTLE

When magnetic soundtracks are edited and then reproduced for motion-picture re-recording or other purposes, the splices in the track frequently cause audible "pops" to be heard in the reproduced program material. Improperly erased magnetic film or tape is one of the causes of this noise which can be eliminated by use of an eraser which does not produce "spokes."

THE AUTHORS consider the subject matter of this paper to be of general interest today because these facts are not widely known and because the answer to a common operational problem may be contained herein. This is a report on a series of tests which we made to identify one source of noise at splices when magnetic film or tape is reproduced. The theory behind these tests is neither novel nor original.

When magnetic soundtracks are edited and then reproduced for motion-picture re-recording or other purposes, the splices in the track frequently cause audible noise — commonly known in the trade as "pops" — to be heard in the reproduced program material. There are many possible causes of these pops, including magnetized splicers, scissors and paper clips, and possibly magnetized heads on the reproducer used during the editing process. All of these can generally be characterized as pops which result from the magnetic film or tape having been in the presence of a spurious magnetic field. All pops in this category can be prevented by locating the magnetizing object and demagnetizing or replacing this object.

A second category of pops which occur at splices can occur even when all of the corrective measures indicated heretofore have been accomplished, and when the film or tape is never in contact with any magnetized object between the time of recording the soundtrack and the time it is played back. Pops of this nature are the result of improperly erased magnetic film or tape and are likely to occur when a residual magnetic signal remains on the film after erasure. In most cases this residual signal is not audible, because when played at normal speed it produces a frequency below that which we can hear or below that which the playback system will reproduce. The residual signal can be made audible by reproducing the track at a speed higher than normal, in which case it is usually heard as low-frequency tones occurring at a repetition

Fig. 1. The RCA MI-10891 Eraser.

Presented on May 3, 1957, at the Society's Convention at Washington, D. C., by I. R. Goshaw for the authors, Carl Shipman and Carl Hittle, RCA Film Recording Sec., Engineering Products Div., Radio Corp. of America, 1560 N. Vine St., Hollywood 28.

(This paper was received on March 21, 1957.)

rate corresponding to a once-around of the feed reel. For this reason this unwanted signal is sometimes called "spokes." It is important to note that the residual signal is rarely constant in amplitude, as evidenced by the fact that audible "spokes" do occur.

To make these tests, a roll of magnetic film was erased on a bulk magnetic film eraser of a type which is known to leave spokes in the film. This film was then reproduced at a higher speed than normal so that the residual signal was clearly audible and points of maximum and minimum signal intensity were located and marked on the film. A series of splices was made in this film by cutting straight across, butting the cut ends together and applying splicing tape across the splice on the back side of the film. This is one of the standard splicing techniques used in editing magnetic soundtracks for motion-picture re-recording.

It was observed that when a splice was made joining a point of maximum residual signal intensity to another similar point, that is, maximum residual signal intensity, no pops occurred at the splice when the track was reproduced. The spoke, of course, was still there, but the splice itself could not be detected by listening. Similarly, splicing points of minimum residual signal intensity together did not cause an audible pop.

However, splicing a point of maximum signal intensity against a point of minimum signal intensity did cause a loud pop at the splice. This is caused by the rapid change in the magnetic field of the soundtrack itself where the residual signal changes abruptly from maximum to minimum, at the splice. This produces an audible sound even when the film is played at normal speed. Further tests indicated that virtually any discontinuity between residual signal levels on the two sides of a splice will cause an audible pop. It is possible to remove a single frame and join the magnetic film back together and create an audible pop, when the film has not been properly erased.

Statistically, it is very unlikely that quiet splices can be made in magnetic film or tape which has residual spokes. If these spokes occur on a once-around basis, related to the feed reel, then they are only inches apart along the length of the film. Between each maximum and the next minimum point there is of course a magnetic gradient. Under these conditions, only good fortune can produce a proper splice.

At the time of these tests, we had under development a bulk eraser for magnetic film and tape without any ferrous or paramagnetic material in the magnetic circuit except the film or tape being erased. The object of this development was to build an eraser which left no perceptible residual signal. A second series of tests was run using magnetic film which had been erased on this RCA MI-10891 Eraser. We were pleased to observe that no spokes were audible even when the film was played at high speed, and that we could not make a splice which would pop when reproduced. It is our opinion that the only solution for the problem of noisy splices caused by a residual magnetic signal is the use of a type of eraser which does not leave any magnetic residue. A paper presented by Grignon and Green at the Society's Convention in Los Angeles in October 1956, and preceding this article in this *Journal*, describes several erasing devices. Participating in these tests, along with the authors, were Kurt Singer of RCA and Tom Gibbons of Minnesota Mining and Mfg. Co.

Two Versatile Laboratory Coating Machines Based on Designs by Samuel B. Grimson

By KARL WEISS and FREDERICK T. O'GRADY

This paper describes the design and construction of two small coating machines, one for film, and the other for glass. Special features of these machines include the adaptability for use with a variety of coating liquids, the ability to be operated with very small volumes of liquid, and simple means for the accurate control of the layer thickness. The film-coating machine incorporates a new coating head which is especially useful for the application of volatile coating liquids and multilayer coatings. The working principles and performance characteristics are illustrated by typical applications.

In the course of work on the preparation of color screens for use in a new color process, it became necessary to make extremely thin and even coatings of gelatin and cellulose esters on plastic film and glass. The specific need was for coating relatively small strips, usually not exceeding one square foot in total area. Literature on coating (both large-scale and small-scale) is voluminous but not very specific, and a great deal of orienting experimentation was necessary to establish useful working principles for small machines. In designing these machines, special emphasis was placed on the flexibility and ease of operation, accurate control of the layer thickness, and a reasonable production capacity in terms of small coatings per day.

I. The Film-Coating Machine

A band of film can be coated by supporting it on two rollers and allowing one roller to dip into a reservoir of coating material. This simple method has been used for the laboratory-scale coating of photographic emulsion.* It is quite obvious that in this mode of application no control can be exercised over the layer thickness. With more fluid materials or compositions containing volatile solvents, the resulting coatings are streaky and quite uneven. If, therefore, even coatings of controlled thickness are desired, an entirely different method of application must be used.

The machine described here is based on the use of a special coating head in which the supply of coating material is regulated by application from a narrow, slot-like orifice.†

Figure 1 is a schematic representation of the machine. A series of rollers supports and guides a 3 by 48-in. strip of film, the ends of which are joined to form a closed band. Although in principle film base of any reasonable thickness can be used, most of the coating work was done with 0.004-in. to 0.010-in. thick cellulose acetate film. After dust and lint are removed by velvet pads, and static charges resulting from this wiping action are dissipated by two Ionotrons‡ located as shown, the film travels past the special coating head which applies the coating material. The freshly coated film travels horizontally for a distance of approximately 2 ft, and then through a zone maintained at 5° to 10° above room temperature.

Motion of the film is achieved by means of a Tygon-coated drive roller which is driven by a gear-reduced synchronous motor. An adjustably mounted tension roller ensures that the film is taut, and in intimate contact with the drive roller.

The operating side of the coating machine is shown in Fig. 2. In its construction, special attention was paid to the accurate alignment of all the essential components. This was accomplished

‡ Ionotron is the trademark for radium-containing metal strips manufactured by the Radium Corporation of America.

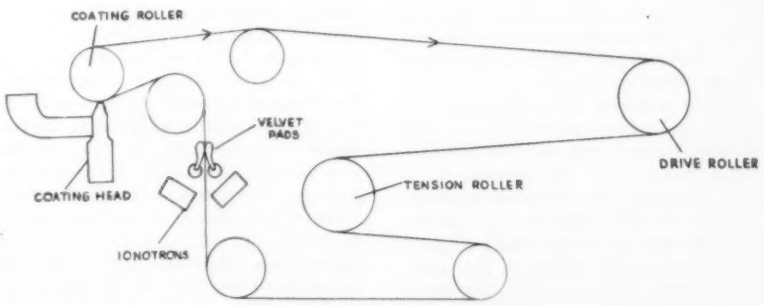


Fig. 1. Schematic representation of the film-coating machine.

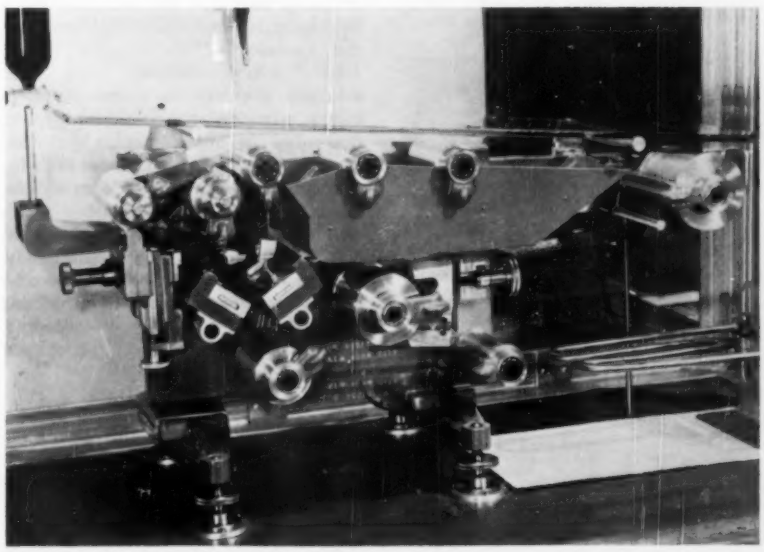


Fig. 2. The operating side of the film-coating machine.

A contribution submitted on May 24, 1957, by Karl Weiss, Dept. of Chemistry, New York University, University Heights, New York 53, and Frederick T. O'Grady. These machines were developed and built in the laboratories of Color Research Corp. of which Mr. Grimson was President until his death in November 1955 (Necrology, *Jour. SMPTE, 65:* 183, Mar. 1956). The authors were associated with Mr. Grimson in this project.

* T. Thorne Baker, *Photographic Emulsion Technique*, American Photographic Publishing Co., Boston, 1941, page 181.

† Samuel B. Grimson, U.S. Pat. No 2,598,908.

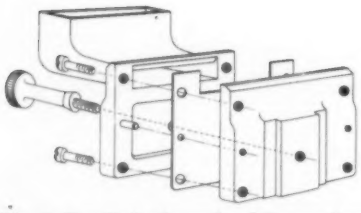


Fig. 3. Detailed schematic of the coating head.

by building the machine around a rigid wall which is supported on sturdy cast-iron footings. Accurately surfaced bosses on the face of this wall serve to orient, perpendicular to the wall, supporting brackets for the rollers. The guide rollers, which are concentric within narrow limits, are suspended in ball bearings. The requirements for exact alignment and concentricity are most critical for the coating roller and the adjacent guide roller. For this reason, these rollers are supported between conical center bearings. The tension roller is mounted on a plate with freedom of motion in the horizontal direction. The coating head is mounted on an adjustable support which locates the coating orifice directly beneath, and parallel to, the axis of the coating roller. A micrometer screw allows the orifice to be brought to a predetermined distance from the film.

Figure 3 shows the coating head in detail. It consists of a reservoir and channel terminating in the slot-like orifice from which the coating liquid is applied to the film. Since the reservoir extends the full length of the orifice, liquid is supplied uniformly to all parts of the orifice. The width of the orifice is adjustable by means of metal shims. Depending on the nature of the coating liquid, widths from 0.01 in. to 0.02 in. have been used. Since two guide rollers contact the film on the coated side, it is desirable to use shims which allow about $\frac{1}{8}$ in. near both edges of the film to remain uncoated. Narrower coatings can be made by reducing the open portion of the shim, and hence the length of the orifice. Since the liquid surface presented to the film is extremely small, this coating head is especially suitable for coating liquids containing highly volatile solvents. Only approximately 40 cc of liquid are needed for its operation. The coating head is easily disassembled for cleaning. Depending on the coating material, between one and three coatings can be made in one hour.

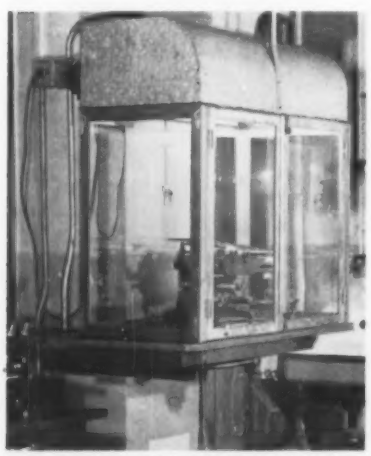


Fig. 4. The machine enclosed in glass-walled housing for better control of atmospheric conditions.

In order to exercise a closer control over atmospheric conditions such as temperature and humidity, which are known to affect the physical characteristics of coatings, it was found advantageous to house the machine in the glass-walled enclosure shown in Fig. 4. The motor is located on the floor to minimize the direct transmission of vibrations.

To make a coating, the machine is threaded with film which is then freed of dust by one pass through the velvet pads and Ionotrons. The coating head is mounted, and the orifice brought to the desired distance from the film. (Useful orifice-to-film separations are between 0.002 in. and 0.010 in., depending on the liquid.) Liquid is poured into the reservoir from a separatory funnel to a height just above the coating lips. At this point a meniscus forms between the orifice and the film, and the machine is started. When the coating process is completed, the head is lowered to break the meniscus, and the velvet pads are removed. After one more pass around the machine, the motor is switched off and the film is allowed to dry.

In a coating device of this type, it is not surprising that the operating characteristics are influenced markedly by the viscosity of the coating liquid. Under some conditions very fluid solutions give rise to uneven coatings due to a tendency of the liquid layer to flow after its application to the film. On the other hand, it is difficult to maintain a meniscus between the film and the coating orifice with extremely viscous solutions. Viscosities between 600 and 1200 centipoises have been found most suitable insofar as flexibility in the controlled variation of the coating thickness is concerned.

The factors which affect the coating thickness are:

(1) the speed at which the film travels;

(2) the width of the coating orifice; and

(3) the separation between the film and the coating orifice.

The last factor exerts the greatest influence, the others being relatively minor. For a given coating liquid, and a constant orifice width and film-to-orifice separation, fast film speeds give rise to slightly thinner coatings than slow speeds. Similarly, wide orifices result in slightly thicker coatings than narrow orifices. A film speed of 35.5 in./min was found to give the best results. With an orifice of constant width used at constant film speed, the coating thickness can be accurately and reproducibly varied over a considerable range by changing the film-to-orifice separation. In fact, within limits, there is an approximately linear relationship between the coating thickness and the film-to-orifice distance. The final (dry) thickness of the coating will, of course, be determined by the properties of the coating solution such as its solid content, and the density of the film-forming material.

This machine has been used to prepare a large variety of color filters by coating dyed gelatin and collodion solutions onto cellulose acetate film. Some typical coating compositions are given below.

Green 1MG-11 (collodion)

Collodion, U.S.P. (General Chemical Corp.)	500 cc
3% Auramine S solution in ethanol	200 cc
5% Brilliant green solution in ethanol	25 cc

Solvent (275 cc) is removed by distillation in order to adjust the dye concentrations and the viscosity, and prior to use, 13.5 cc of Cellosolve are added.

Blue BG-7 (gelatin)

Gelatin (Dunn #3538)	20 gm
5% Malachite green solution	15 cc
3.5% Crystal violet solution	15 cc
5% Chrome alum solution	5 cc
Water to a final volume of	200 cc

This solution is used at a temperature just above its setting point.

When used with a 0.0148-in. wide orifice and a film-to-orifice separation of 0.005 in., the green collodion solution yields a coating whose dry thickness is 5 μ. Micrometer measurements on the film are not sufficiently sensitive to detect variations in the coating thickness. An accurate evaluation of the thickness variations over the whole area of the coating can, however, be made by optical density measurements. Such measurements indicated a maximum variation of 1%.

The machine has also been used to coat photographic emulsions. For this purpose, a silver-plated coating head is used. The small quantity of emulsion which is involved can be kept liquid by prewarming the trough. The ability to apply extremely thin coatings makes the coating head particularly useful for the preparation of multilayer coatings.

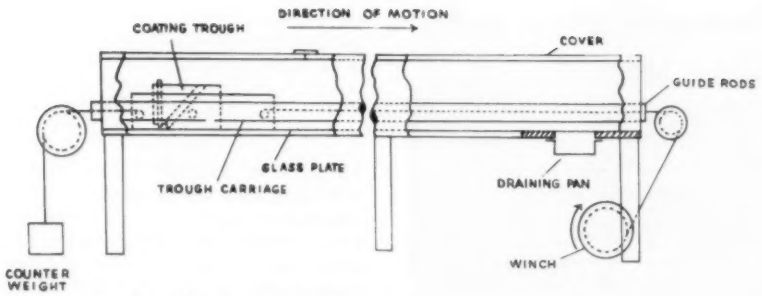


Fig. 5. Schematic of the glass-coating machine.

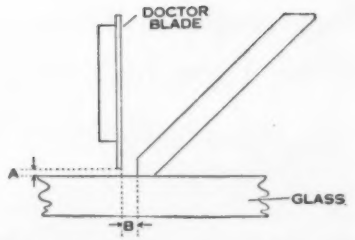


Fig. 6. Detailed schematic of the V-shaped coating trough.

II. The Glass-Coating Machine

A number of methods are available for the application of coatings to rigid supports such as metal or glass. The simplest of these merely involves spreading a measured quantity of coating liquid over the levelled support, and allowing the solvent to evaporate. This works well with solutions of gelatin and related substances, but is not useful for liquids containing highly volatile solvents. In other methods, the coating material is applied by spinning, spraying or by spreading with a doctor blade.*

The present machine is based on a modification of the doctor-blade method in which a V-shaped trough is used, the front end of which constitutes the spreading blade. This type of trough can be operated either by moving the plate to be coated under the trough, or alternatively, by moving the trough across the plate. In view of the variation in thickness encountered in even the highest-quality commercial plate glass the latter mode of operation was adopted.

As shown schematically in Fig. 5, the machine consists of a 24-in. long, glass-covered alley designed to accommodate one 18 by 4 by $\frac{1}{8}$-in. piece of plate glass, or a number of smaller, adjoining glass plates of identical thickness. The V-shaped coating trough and the supporting carriage in which it rides both rest on the plate to be coated. Two cylindrical rods, accurately parallel to each other, serve as side-guides for the carriage. The carriage (and trough) is moved across the glass surface at a speed of 30 in./min by means of a motor-driven, threaded winch which winds a wire cable attached to the carriage. A heavy weight, attached to the rear of the carriage with another wire cable, prevents jerky, uneven motion.

The trough, the main parts of which are made of phosphor-bronze, has a "V" angle of 45° as shown in Fig. 6. It is easily dismounted for cleaning. The doctor blade consists of a $\frac{1}{32}$-in. steel sheet, accurately finished and fitted with a blunt spreading edge. Both the height of the doctor blade above the glass, A, and the width of the channel at the bottom of the trough, B, are accurately adjustable. The optimum channel width depends on the properties of the coating liquid; with the collodion compositions described previously, a width of 0.010 in. is suitable. The maximum capacity of the trough is approximately 25 cc, and the width of the coatings it produces is 3 in.

Prior to coating, the glass is cleaned by immersion in a hot solution of sodium dichromate in concentrated sulfuric acid followed by thorough washing with water. For most coating materials it is necessary to apply a substratum to the glass if the coated film is to adhere properly. The following composition has been found useful for collodion coatings.

Substratum GS-5

Gelatin (Dunn #3538)	5 gm
5% Chrome-alum Solution . . .	5 cc
Water to a final volume of . . .	1000 cc

This solution remains liquid at room temperature and can be easily applied with a spinning device.

The procedure for making a coating is as follows. The glass plate (or plates) is freed of dust with a stream of compressed air and placed in the bottom of the coating alley. The trough and its carriage are positioned at the starting end, and the doctor blade is adjusted with the aid of a feeler gauge. A thin metal plate (not shown in the diagrams), which rests on the sloping wall of the trough and extends to the blade, prevents premature seepage of coating liquid when the trough is filled. To start the coating operation, this plate is withdrawn and placed so as to serve as a cover for the trough, the alley is covered, and the machine is immediately set into motion. At the end of the run, the trough comes to rest on a metal plate which is level with the coated glass. The excess coating liquid drains through an opening in this plate into a small pan. Rapid drying, especially with highly volatile coating liquids, often gives rise to surface defects such as an "orange peel" effect. The wet coating is, therefore, allowed to dry slowly under cover, aided by a heating element (not shown) which is located beneath the coating alley and extends over its whole length. For collodion coatings, the capacity of the machine is approximately one coating per hour.

The thickness of the coating is determined entirely by the setting of the doctor blade. The wet film laid down is, however, generally of smaller thickness than the clearance of the blade, due to the operation of shearing forces on the liquid. The magnitude of this effect, and hence the discrepancy between the size of the gap and the thickness of the layer it applies, depends on the width of the blade and on the flow properties of the liquid.

In a typical application of this machine, glass was coated with the previously described green collodion composition. With a blade clearance of 0.005 in., the final (dry) coating thickness is 4μ. Optical density measurements showed that, except for the initial $\frac{1}{2}$ in., the thickness is constant within $\pm 1\%$ over the entire area of the coating.

* H. A. Gardner and G. G. Swain, *Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors*, H. A. Gardner Laboratory Inc., Bethesda, Md., 1950, chapter 9.

Superimposed Titles on Black-and-White and Color Films by a Photo-Resist Method

By W. I. KISNER and J. J. MURRAY

A method for adding titles to conventional processed image-bearing photographic materials is described. The procedure involves preparation of a black-and-white title positive, coating of the film with a photo-resist material, exposure and development of the resist, selective removal of the title images by the action of destructive solutions and, finally, removal of the resist. The method has been successfully used with Kodachrome, Ektachrome, Eastman Color Print Film and black-and-white films. Applications include titles for motion-picture release prints, slidefilms and individual transparencies.

IT IS FREQUENTLY desired to add titles or various types of line images to processed films containing picture images. Such superimpositions are used for a number of purposes, including captioning of motion-picture release prints with foreign language titles, preparation of titles for slidefilms and individual transparencies and addition of continuous or dotted lines, insignia, arrows and other symbols to slides used for lectures, television transmission, etc.

Presently used commercial methods of adding titles to processed films utilize a metal stamp containing the type matter. In one method, the stamp is heated to a temperature which is high enough to melt the emulsion layer or layers of the film as it is pressed against it, thus removing the emulsion from the areas occupied by the type matter. In another method, the emulsion layer of the film is first coated with wax. The metal stamp, heated to a somewhat lower temperature than in the previous method, is pressed against the coated surface and the wax is thereby selectively removed. The film is then treated with a solution of sodium hypochlorite, or other oxidizing agent, which removes the emulsion not protected by the wax.

The method described in this paper eliminates the need for making the metal type and also the need for heating of stamps or other types of stencils. In this method, a photo-resist image is used in place of wax to protect the film in the desired areas. Formation of the image by photographic rather than mechanical means yields titles having better sharpness characteristics than those obtained by the other methods.

Resist Material

The resist material used in this method is Kodak Photo Resist (KPR). This is an all-plastic, presensitized, liquid surface-coating material used in photomechanical reproduction. It serves as an acid-resistant material in various etching techniques and also as an ink-receptive material for preparing surface-type photolithographic plates. KPR adheres well to various types of surfaces and is capable of reproducing fine image detail. Any method of application capable of giving a smooth coating may be used, such as spraying, dipping, whirling or rolling. An area of about 400 sq ft can be effectively spray-coated with one gallon of KPR. In the use described here, this is equivalent to about 3,500 ft of 35mm film per gal.

After drying, the coated surface is waterproof and resistant to all commonly used acids and alkalis. The stability of the coating is excellent and, if desired, coatings can be made several days or weeks before exposure. The sensitivity is unaffected by atmospheric changes. The coatings can be handled under moderate yellow tungsten or gold fluorescent illumination for as long as 30 min without danger of fog. White fluorescent illumination should not be used however, because fog can result under these conditions for exposure times as short as 6 sec.

The coating is sensitive to ultraviolet radiation and for this reason the exposure is normally made using a carbon-arc lamp. Areas which are exposed to ultraviolet radiation become selectively hardened. The unexposed areas are removed by a developer containing organic solvents.

Certain precautions should be observed in handling KPR and KPR Developer. Adequate room ventilation should be provided to avoid any irritation from solvent vapor during the spraying and drying operations. KPR Developer is flammable and should not be used near open flames or sparks. Local exhaust may be needed in the vicinity of the developer tanks or trays and during the application of KPR.*

Presented on October 4, 1957, at the Society's Convention at Philadelphia, by W. I. Kisner (who read the paper), Motion Picture Film Dept., Eastman Kodak Co., 343 State St., Rochester 4, N.Y., and J. J. Murray, Research Laboratories, Kodak Park, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on September 3, 1957.)

* Further details pertaining to the characteristics of KPR and associated materials are available upon request to the Graphic Reproduction Sales Div., Eastman Kodak Co., Rochester 4, N.Y.

Preparation of Artwork

The artwork for the titles or other images to be superimposed on the picture background is prepared in the usual way using conventional media, such as letterpress or offset printed copy, ink-lettered cards, plastic letters, Fototype†, etc. Experience will determine how much fine detail can be included in the artwork for the particular application and the extent of reduction. During the treatment of the film in the oxidizing bath, some spreading of the image does occur. On this account, certain type faces having fine serifs may not reproduce satisfactorily. Generally speaking, block-type letters and hand-lettering without extremely fine detail are preferable.

Preparation of Title Negative and Positive

The artwork is photographed on a high-contrast material, such as Eastman Fine Grain Release Positive Film, Type 5302. The film is processed in a normal positive-type developer, such as Kodak D-16 Developer, to yield a high-contrast negative. The latter is then printed onto the same material and processed in Kodak D-16 Developer to give a positive with dense black letters and clear surround.

(Examples of superimposed titles on Kodachrome and Ektachrome Films and Eastman Color Print Film, Type 5382, were prepared in the form of 2 by 2-in. slides for the oral presentation of this paper. For three of these slides, the titles were reduced so as to be included in the frame area of 24 by 36-mm normally used for 2 by 2-in. slides. A fourth slide, made on Eastman Color Print Film, was prepared to simulate the reduction conditions used when making tiles for slidefilms and motion-picture release prints. In this case, the frame area in which the title is included was the same as that of a standard 35mm sound motion-picture release print, i.e., 0.600 by 0.825-in. Figure 1 shows the results obtained on Eastman Color Print Film.)

The procedure used for making these illustrations is described in detail below. Suggested process modifications are given for application of the method to larger scale production, as for large groups of transparencies, slidefilms and motion-picture release prints.

Procedure for Making Titles on Individual Transparencies

Coating: The color film (Kodachrome, Ektachrome or Eastman Color Print

† Fototype, Inc., Chicago, Ill.

Films) was spray-coated* with a mixture of equal volumes of KPR and toluene† and allowed to dry in a ventilated hood. Coating was carried out under moderate yellow tungsten illumination.

Exposure: The coated film was placed in a printing frame in contact with the title positive and exposed to a 30-amp arc lamp at a distance of 3 ft for 2 min. The exposure time is not critical for this type of line reproduction; 1 min is adequate and 4 min is not excessive under the same conditions.

Development: The resist image was developed in solutions containing organic solvents in order to remove the unhardened areas which were beneath the title positive letters and consequently had received no exposure. Development was carried out at room temperature (70 to 75 F). Because of differences in the support characteristics of the separate films, two different solutions were used:

Kodachrome and Ektachrome Films — 15 to 30 sec in trichloroethylene†

Eastman Color Print Film — 2 min in Kodak Photo Resist Developer†

Washing and Drying: In order to remove any residual unexposed KPR, the resist image was then washed with tap water for 30 to 40 sec and excess water droplets were removed by blotting with a towel. The film was then completely dried in forced warm air at 100 to 150 F.

Etching: To destroy the emulsion in the areas occupied by the letter images, the film was treated in a 0.5% solution of sodium hypochlorite for about one min at normal room temperature. This is a rather critical step and it must be timed accurately since insufficient treatment in the solution will result in incomplete destruction of the areas to be removed and overtreatment will cause undercutting and spreading of the image. The above concentration of hypochlorite appears to offer satisfactory control for this hand operation but other concentrations might conceivably be used for continuous operation.

The 0.5% sodium hypochlorite solution can be prepared conveniently by dilution of one volume of an ordinary household bleach, such as Clorox (5.25% hypochlorite) with nine volumes of water.

The film was washed again for a few seconds in tap water to remove the bleach solution and dried with the aid of toweling and warm forced air.

Removal of Resist: The final step is the removal of the resist image from the background picture area which is carried out by gentle swabbing of the entire surface with cotton moistened with trichloroethylene. As noted above, certain precautions should be taken with this toxic material.

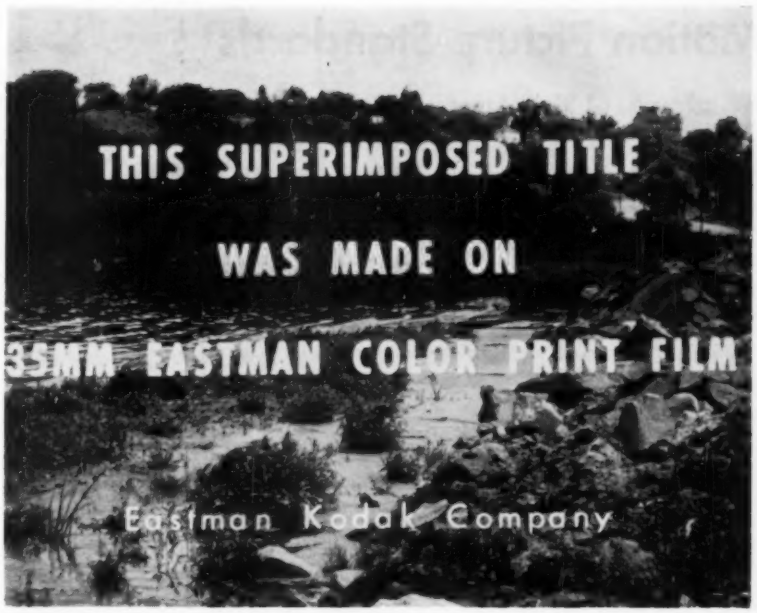


Fig. 1. Enlargement from 24 by 36-mm frame area.

Modification of Procedure for Production Use

The foregoing procedure is quite satisfactory for use with individual transparencies. Certain modifications should be made, however, if large groups of slides are to be prepared or where it is desired to use the method for making titles on slidefilms or motion-picture release prints. No actual large-scale production has been done in this connection but some suggestions can be offered which should be helpful for such work.

Large groups of individual transparencies can be rack-mounted and spray-coated at one time, thus minimizing waste of the KPR material. Processing can be carried out in deep tanks using suitable processing racks.

For slidefilms and motion-picture release prints, it would appear quite feasible to use bead- or wick-type applicators for applying KPR by continuous means, provided that some arrangement is made for rapid drying of the coating to minimize film curl.

Exposure of the coated film can be reduced considerably by using arc sources of higher intensity, by suitable reflectors and by shortening the distance from source to exposure plane. For example, in a motion-picture printer, it should be possible to utilize a reflector-type arc lamphouse, such as is used for a theater projector. By concentrating the light flux on the printer gate, the exposure time could probably be reduced to the order of one second or less. Mercury vapor and xenon flashtubes might also be considered as alternative light sources.

The chemical processing steps could be carried out by continuous machine to provide the appropriate treatment at each stage. Development could be carried out by deep tank using a machine speed and proper path length for the required time. As an aid in drying of the film after the washing operations, efficient air squeegees, followed by impingement-type dryers, should be useful. The etching operation could be done by simple immersion treatment with appropriate adjustments in the hypochlorite concentration. Finally, the removal of the resist could be accomplished with a suitable buffer wheel rotating in a well containing the trichloroethylene solvent, the well being properly enclosed to minimize contamination of the surrounding atmosphere.

The procedure for adding superimposed titles to black-and-white prints is the same as that used for adding titles to prints on Eastman Color Print Film.

Conclusion

The method described is offered to the industry as an alternative method for making superimposed titles on processed films using commercially available materials.

It may also find some application in preparation of cells for animation purposes.

* Coating with a hand atomizer or camel's-hair brush is also a satisfactory method.

† Toluene and KPR Developer are flammable and care should be taken to avoid their use near open flames or sparks. Both toluene and trichloroethylene are toxic. Care should be taken to avoid prolonged breathing of vapor or prolonged or repeated contact with the skin.

Motion Picture Standards

Withdrawal of Two American Standards

On September 30, 1957, the American Standards Association approved for withdrawal the following American Standards:

Z22.29–1948, Dimensions for Theatre Projection Screens

Z22.78–1950, Dimensions for Mounting Frames for Theater Projection Screens

These two standards were reviewed by the Film Projection Practice and Standards Committees. A thorough investigation disclosed that they no longer represent current practice or future trends and it was recommended that they be withdrawn. –*J. H. S.*

Revision of American Standard

Published here is American Standard PH22.40-1957, Photographic Sound Record on 35mm Prints (Revision of Z22.40-1950), which was approved by the American Standards Association on October 1, 1957. This standard does not differ from the proposal published for trial and comment in the November 1956 Journal, where a summary of its development will be found. –*J. Howard Schumacher*, Staff Engineer.

American Standard

Photographic Sound Record on 35mm Prints

ASA

PH22.40-1957

Revision of Z22.40-1950

UDC 778.534.4

1. Scope

1.1 This standard specifies the location and dimensions of variable area and variable density sound records for the photographic printing of sound on 35mm sound motion-picture prints.

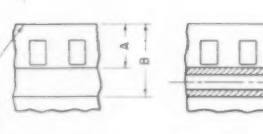
1.2 This standard specifies the area scanned in the sound reproducer.

2. Dimensions

2.1 The dimensions and location of the sound record shall be as specified in the diagram and table.

2.2 The sound record as printed on the film shall be displaced from the center of the corresponding picture by a distance of 21 frames in the direction of film travel during normal projection.

2.3 When the sound record is reproduced, the distance from the center of the projector aperture to the sound scanning point shall be adjusted to bring the picture and sound into synchronism for the average observer. Usually this separation will be 20 frames, and this will provide synchronism for an observer at a distance of 50 feet from the speaker.



Dimension	Inches	Millimeters
A	0.192 ± 0.001	4.88 ± 0.03
B	0.308 ± 0.002	7.82 ± 0.05
C	0.076 ± 0.001	1.93 ± 0.03
D	0.244 ± 0.002	6.20 ± 0.05
E	0.100 + 0.000 — 0.008	2.54 + 0.00 — 0.20
F	0.244 ± 0.001	6.20 ± 0.03
G	0.084 ± 0.001	2.13 ± 0.03

Approved October 1, 1957, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

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APPENDIX

(This Appendix is not a part of the American Standard Photographic Sound Record on 35mm Prints, PH22.40-1957, but is included to facilitate its use.)

The picture-sound separation is specified in Section 2 in two different ways:

(1) For laboratory printing—21 frames

(2) For projector threading—20 frames

This seems to imply that the printing operation establishes the 21-frame separation, but this, in fact, is not so. The printer adds a 20-frame separation to an existing one-frame differential.

The one-frame difference results from the fact that editorial or "in-line" sync (picture and corresponding sound aligned side by side) is changed by one frame to accommodate the mixer in a rerecording studio where the mixing console is approximately 50 feet from screen and speaker. Under normal conditions, sound travels about 1100 feet per second and thus 45 to 50 feet during the 1/24 second that a frame is in the projector aperture. The sound at the speaker is thus one frame, in time units, ahead of that same sound at the mixer's position. The mixer, to adjust for sync at his location, automatically calls for a one-frame increase.

In the projector, a 21-frame threadup separation will bring corresponding picture and sound to the screen and speaker at the same instant; a 20-frame threadup separation produces this synchronous condition about 45 to 50 feet from the screen; a 19-frame threadup separation results in synchronism at about 90 to 100 feet from the screen. Consequently, the projectionist in a drive-in theater will thread 21 frames since the speaker is within a few feet of the patron; in a theater of moderate size, he will thread 20 frames and in a very large theater, he may thread 19 or 19½ frames.

Achievements and Responsibilities

By BARTON KREUZER,
SMPTE President

AT OUR LAST MEETING, I reported to you concerning the progress of the Society. At that time there were student chapters and the newly founded Canadian Section to welcome. These are milestone events, occurring at intervals and resulting in some cases from years of planning and effort.

In the last six months since our previous Convention, there has been much progress also — although of a different nature.

Our membership growth, stimulated by the efforts of Ed Warnecke and his Membership Committee, continues at the high rate of recent years and now numbers nearly 6,000. In parallel fashion, Reid Ray, as Chairman of the Sustaining Membership Committee, reports the total of sustaining members as 121, including several prominent newcomers. Our papers program is full and the Board of Governors has been willing to break with precedent and try this "split-week" type of Convention.

In the midst of technical paper sessions and what we trust will be pleasant social events, other serious Convention activity takes place. Perhaps not everyone realizes that some 17 engineering, editorial, and other committee meetings during the week will continue preparing standards, which may be adopted, some of which will become international and all of which will further the solution of industry's technical problems; and others will be improving our *Journal* and other publications and operations. It should be noted that these meetings are open to all.

There has been much accomplished through the courses of study sponsored by Past-President John Frayne's Educational Committee in Hollywood, as well as the courses provided similarly by Subchairmen Jim Kaylor and Ed Schuller and their committees in the East under Vice-Chairman Herb Barnett.

There is further accomplishment in Section Vice-President Ed Stifle's continuing effort, not only with respect to Sections' activities but on behalf of student chapters and the Student Paper Competition; the assemblage of outstanding technical programs by Ben Plakun and his co-workers, with Deane White primarily responsible for the 82d Program; and last, but certainly not least, the continuous improvement of the Society's *Journal* by the staff, our Editorial Vice-President Glenn Matthews, and the Board of Editors under the able chairmanship of Pierre Mertz.

All of these, I am sure, will agree they have been able to build well because of the foundation supplied by their predecessors in office.

New Trends

In checking further on progress: in our Convention technical program and recent *Journals* we find papers on videotape recording, on military television applications, on new phases of high-speed photography, on international television, and on instrumentation, as well as the more familiar SMPTE topics. These are trends which in many ways began last spring in Washington.

Other changes are manifest in the several industries of which our Society is a part. Television is adding color to monochrome pictures as films did long ago.

Closed-circuit television is active in many guises. In one form, as "pay" or "toll" TV, it has been reviewed recently by the FCC and a way opened for possible test programs. As a tool for sales promotion it has been used recently to bring a new product message in color to some 15,000 dealers, newsmen, and others in private showings in 150 cities.

In entertainment form, less than two weeks ago it brought a championship boxing match to more than a half million sports fans in 174 theaters in 131 cities. Some of these, as our Canadian members have undoubtedly noted, were located for the first time in three Canadian provinces.

Those who attended the interesting session at the Walter Reed Hospital in connection with the Convention last spring in Washington know of closed-circuit television progress for medical usage. Scarcely a week passes that does not herald some further usefulness in the educational field of closed-circuit television and sound motion pictures.

These are the types of changes that spell progress for the industries with which our Society is associated, and also progress for the Society and our members, provided, of course, that each of us stays alert and recognizes both our responsibilities and our opportunities as they arise. I believe, too, that the past can be drawn upon for some supporting evidence.

The formation of SMPE in 1916 by a handful of engineers coincided with a public acceptance of silent motion pictures. In the home, aural entertainment was provided by a wind-up phonograph, piano, and other musical instruments. In theaters, the silent motion picture attracted an increasing audience. Even the titles of that era emphasized that the picture was visual only. Vitagraph's *Silent Strength*, Paramounts' *Silent Partners*, and Universal's *Silent Lady* were typical titles.

In 1922, along with Jackie Coogan, Norma Talmadge and Rudolph Valentino, the American public saw, or rather heard, radio. No more than 100,000 home radios were in use by the end of 1922. By 1928, these numbered approximately 8,000,000, and by 1928 our membership had more than tripled to about 350 active members. Then came sound motion pictures, a story too well-known to repeat here, but as the motion-picture industry expanded, the membership of this Society continued to grow.

The war years brought about broader use of films for military as well as civilian purposes, and when peace came, drive-in theaters provided an additional stimulus.

Radio sets had now risen to about 50,000,000 units, but a new form of home entertainment appeared. Some five television stations broadcast programs sporadically to a handful of TV receivers. By 1946 our members reached 2,300.

By 1950 there were over 10,000,000 television receivers; SMPE became SMPTE; and membership stood at 3,200. Last year there were 42,000,000 sets and 5,600 members.

Presented at the Get-Together Luncheon on October 4, 1957, at the Society's Convention at Philadelphia.

With statistics like these a matter of record, it is not surprising that the eyes of many in the several industries involved have focused on the Bartlesville, Oklahoma, closed-circuit television venture which started about a month ago. Certainly it is too early to draw conclusions about the future of Telemovies, but one wonders whether Warner Brothers' *Pajama Game* will have the same effect on entertainment as did their release of *The Jazz Singer* 30 years ago.

Motion pictures, after all, represent more than half of the total television time each week. These shows are programmed by two major sources: first, releases of pre-1948 motion pictures; and second, films produced principally for television. The first group is of particular importance to the motion-picture industry since pre-1948 pictures will mean extra income of over $140 million over a period of several years. The second group may eventually top the first. By the end of 1957, 39 producers will have produced 108 individual telefilms for a gross of $115 million, and SMPTE membership will have risen to 6,000.

Educational Crisis

We have talked briefly of the educational uses of closed-circuit television, but certainly a moment's additional attention to this important field seems appropriate. The educational crisis is a problem of which we are all aware. More students, inadequate facilities, and fewer teachers will make this problem greater each year. The techniques of using television and motion pictures for education are in their infancy, but they do offer great hope.

This year about $2.5 million will be spent for television equipment in schools, principally by the Ford Foundation and its agencies. Within five years this expenditure will approach $20,000,000. There is a challenge for Society members in the modification for educational purposes of the equipment and techniques developed for entertainment purposes, whether TV or motion picture.

Technical Library Facilities

If we return now to the proposal to acknowledge both our opportunities and responsibilities, I would nominate for consideration the goal, for our members and their industries, of improved technical library facilities. It is too early to predict the method — it is unlikely that the Society will suddenly appear as the owner of a marble building full of books and adequately staffed; it may be that facilities exist that could be more effectively utilized through association in some way with the Society. I am sure that the best procedure is not yet known to us, but we are examining the situation further. If anyone has any ideas on the subject, may I suggest sending them to Society headquarters.

The combination of national security requirements, accelerated technological achievements, increasing population, higher personal incomes, shorter working hours, more leisure time, demands for better health and better education, offer a challenge far greater than we have ever faced before. In the past our Society and the industries with which it is associated have met many challenges, and as I have shown you, it has grown with each: with radio, with sound, and with television.

If, both as individuals and collectively, we continue to exert the same effort and creativity as in the past, I am certain our Society will grow with the challenges posed by the many new fields of technical endeavor in which we are engaged.

Some Engineering of the Past and for the Future

By T. A. SMITH

(These are the remarks made at the Get-Together Luncheon at Philadelphia, October 4, 1957, by Mr. Smith, who is Executive Vice-President, Industrial Electronic Products, Radio Corporation of America. Except for very minor changes, Mr. Smith's engineering "editorial" is presented below.)

FOR HISTORICAL REASONS and for present interests, it is especially appropriate that your Society should meet in Philadelphia. Not only is the Philadelphia area, or as it has become increasingly known, the Delaware Valley area, an electronics center, but also it has been a center of science as far back as the time of the eminent Dr. Franklin. For those who are not well acquainted with Philadelphia, may I say that practically everything here, with a few exceptions, was started by William Penn or Benjamin Franklin. One such exception is, of course, Eldridge Johnson, of Victor Talking Machine fame, who invented the Victrola. Here, too, in the Delaware Valley, radio found its later development and some of the birth pangs of television took place.

In this locale some of the very first sound motion pictures were produced — not just scored or dubbed (they did that, too), but actually photographed. Years later the same studios were pressed into service once more for some of the first theater or large-screen television development work.

So it is appropriate that, at a time when the long-forecast marriage of the motion-picture and television industries seems to have settled down and to be producing healthy offspring, the Society should honor this city with its presence.

Just as the motion-picture, television and related industries represented here today have broadened their spheres of interest, and in so doing expanded the base of your Society, so, too, has electronics greatly broadened its outlook.

The Beginnings of Electronics

The initial effort of electronics engineers was devoted to telegraph communications. Then came broadcasting and audio transmission. The joining of electronics with

photography had dual origin — in the sound motion picture and in television. Now we find ourselves using the electronic art for many other purposes — for computation, for recording and handling data and for control.

It has become possible for electronics to do more than to convey a message to the human brain in the form of words, sounds or pictures. By endowing electronic devices with stored instructions, it becomes possible to remove the human brain from the direct chain of command and to allow electronics to act directly. We have, so to speak, been pushed to the sidelines by the vacuum tube. We may watch, take over if needed, but if we choose to go out for coffee, our machines carry on. We are relegating ourselves to the position of coach, rather than player — we still supply the strategy but avoid the hard knocks or the tedium of each operation.

Electronic systems can act much faster and more accurately than a tired human brain. For example, we can shoot our guns or rockets with greater accuracy when electronics takes over an interceptor aircraft. In the relatively new field of electronic control, electronics harnessed into systems operation has demonstrated a fantastic ability to perform with unbelievable speed, efficiency and economy untold tasks in management, business and production.

Within the past decade electronics has developed almost unlimited power to duplicate and amplify man's senses and to match, and sometimes outdo, many of his abilities and capabilities. We have seen the development and application of electronic devices and systems which can see, hear, feel, measure, control, sort, count, compute and calculate. These devices can memorize fact and information and, on demand, recall them for useful purposes. In the laboratories, important advances are being made which promise machines and systems that will respond to the spoken word, and electronic systems capable of scheduling production and controlling manufacturing and commercial processes.

Electronics and Economic Progress

Translated in terms of tomorrow's industry, arts and sciences, this progress gives promise of an era in which our present concepts of speed, efficiency and economy will be so obsolete as to be harmful to those who retain them. Today, no manufacturer, no motion-picture producer, no television broadcaster would consider entering a new venture without the latest in modern facilities and equipment. In the immediate tomorrow it may be impossible to remain competitive without the aid of systematized electronics.

Although we may have taken the human brain out of the direct line of operations, we have not removed it from the picture. It has been said that computers are rather stupid. They are effective only if directed by human intelligence; this is really the new thing that has happened to electronics engineering. The intelligence which must be used to design and to instruct our complex electronics of today is broader and more all embracing than at any time in the past.

This is to be expected. As our devices become more complex, it takes more intelligence to design them and to make them perform. It is an axiom that to teach a dog tricks, you must be smarter than the dog.

Today, some of our electronic tasks require us to consider events taking place at separated time intervals at widely spaced locations, as well as the characteristics of a great number of devices of all kinds, linked together by electronics.

Systems Engineering

We have reached the point where systems engineering has become the starting point for our complex electronics. To design and control a series of electronic equipments linked together takes the specialized knowledge of the systems engineer.

This is not, of course, new to SMPTE. The standards of motion pictures reflect early systems engineering to enable all of the elements of a widespread system to function satisfactorily. Those systems standards even took into account human psychology, which is made much of in some of the newer electronic systems.

Engineering has today extended far beyond the area of merely looking at a device and now considers complete services, industries or enterprises. It thinks not merely of how to do a job, but how to do it economically, reliably and with practical considerations.

Engineering training must, therefore, aid those equipped for broad thinking to practice with all of the knowledge available. If we can have top-notch systems engineers, the need for a large number of engineers is less important. We have heard much about the number of engineers being turned out in Iron Curtain countries. Many believe that in the race for technical supremacy, the winner will not necessarily be the country with the most, but the one endowed with the best systems engineering.

It seems vital, therefore, to provide adequate means for educating our engineers in systems thinking. I mention this here not merely because some of the early systems engineering courses were given in Philadelphia but because the scope of interests of SMPTE members is indeed very broadly involved with systems engineering.

The Example of Television

With this Society's more than passing interest in television, we should take note of it as one of the few national enterprises which was planned on a systems basis. There is no doubt that this planning and engineering contributed to the rapid growth of television. I think you will agree that television has had a very profound effect on our national interests and even on our economy. Perhaps in the not too distant future, we shall have some other broad system, devised by engineers, which will give a similar lift to our national economy.

There can be little doubt that we are in a changing industrial world. The Electronics Revolution is developing faster than any major industrial changes which preceded it. With this changing world, however, comes an inseparable challenge — to those of us in the electronics industry as well as to those in the arts and sciences. It is the challenge to seek out, to bring to light, and to direct into constructive channels the new tools and techniques developing out of this increasing knowledge of electronics.

Applied as a means of improving and speeding our industrial, artistic and scientific pursuits, electronics has the power to strengthen the nation and its economy and to ease and enrich the lives of each of us to levels almost beyond the scope of imagination.

news and reports

83d Convention Program

Before the 82d Convention had begun, Papers Committee Chairman Ben Plakun and 83d Program Chairman Herb Farmer had their general plans made in cooperation with Editorial Vice-President Glenn Matthews. Author Forms for the 83d Convention have been prepared and in modest circulation for the past six weeks.

Deadline for abstracts to reach the Program Chairman is February 3. Deadline for advance copies of manuscripts is March 17. Author Forms are available from Society Headquarters, the Papers Committee Chairman and Regional Chairmen (p. 8, April 1957 *Journal*, Part II), but preferably from: Herbert E. Farmer, c/o Cinema, Univ. of Southern Calif., University Park, Los Angeles 7.

The complete list of 83d Convention Topic Chairmen will be published in the next *Journal*.

An exhibit of the latest motion-picture and TV equipment will be a feature of the Convention. Exhibit Chairman is John B. Olsson, c/o Houston-Fearless Div., 11801 West Olympic Blvd., Los Angeles 64.

International High-Speed Photography Congresses

The First International High-Speed Congress took place in 1952 concurrently with the 72d Semiannual SMPTE Convention in Washington, D.C. It was there planned that a similar congress should be held in about two years' time in Europe and in 1954 the Second International Congress took place in Paris. At this meeting it was agreed that further congresses should be held at two-year intervals and a schedule was set up calling for congresses in England in 1956, Germany, 1958, and U.S., 1960.

The 1956 congress took place in London, September 10–15. Scientific developments of great significance to the art were covered at this meeting and the personal contact made possible among specialists from different countries was most valuable. It was generally agreed that a two-year interval between meetings is not too little in view of the increasing importance of high-speed photographic techniques in such areas as gas dynamics, ballistics, thermo-hydrodynamics, rocketry, detonations, nuclear weapons, thermo-nuclear fusion, etc.

The 1958 Congress will be held September 22–27 in Cologne, Germany. It will take place during the same week as the Photokina, the annual photographic exposition held in Cologne, so that visitors will be able to attend both events. The Photokina management will provide a special section at the exposition where manufacturers of high-speed equipment will have an opportunity to display their products.—*Dr. H. Schardin*, 10 Rosenstrasse, Weil am Rhein, Germany.

82d Convention

An excellent and well-balanced program of technical papers, a series of highly enjoyable social occasions scheduled over the unfamiliar setting of a weekend, the fine accommodation provided by the shiny new Sheraton Hotel, and 500 registrants from all parts of the country, were all factors in making the fall convention in Philadelphia, October 4–9, both valuable and stimulating.

The Philadelphia area, where the Society was meeting for the first time in more than thirty years, has long had a heavy concentration of the electrical and communications industries; in recent years it has grown to be one of the most important television and electronics centers in the country. This note was stressed at the start by Theodore A. Smith, Executive Vice-President, Industrial Electronic Products, Radio Corp. of America, who gave the keynote address. After Barton Kreuzer, as SMPTE President, had officially opened the proceedings with his report to the Society, he introduced Mr. Smith. The report and the address appear earlier in this *Journal*.

Annual Business Meeting

The annual business meeting of the Society, called on this occasion to vote on a number of proposed amendments to the Bylaws, details of which were published in the September *Journal*, was held at the beginning of the afternoon session on Friday, October 4. Since a sufficient number of voting members was not present to constitute a quorum, the amendments could not be voted on, and the matter was returned, as the Constitution provides, to the Board of Governors for action.

Program

The man most responsible for organizing the fine selection of technical papers at this convention was Program Chairman Deane R. White. He was ably assisted in varying portions of his task by the Topic Chairmen: *Ellis W. D'Arcy*, Bilingual Films for Intercontinental Television; *Herbert Barnett*, Closed-Circuit Television; *J. Paul Weiss*, Color Photography; *H. E. Behrens*, Film Projection Practice; *D. Max Beard*, High-Speed Photography; *J. B. McCullough*, Industry Milestones; *John G. Stott*, Laboratory Practice; *Max C. Batsel*, Military Uses of Television; *Frank L. Marx*, Projection Television; *Edward Schmidt*, Sound Recording; *Petro Vlahos*, Studio Lighting; *Richard S. O'Brien*, Television Studio Practice; *George H. Brown*, Video Tape Recording.

Several sessions drew unusually large audiences. The group of closed-circuit television papers, followed by three papers on video tape recording, on Saturday afternoon, was one of these. Another was the Tuesday evening session on inter-

G. Carleton Hunt, Convention Vice-President, taking call on pocket-sized RCA radio receiver and transmitting instructions to Miss Regina M. Przywara of the convention staff.

Happy days are here !!!

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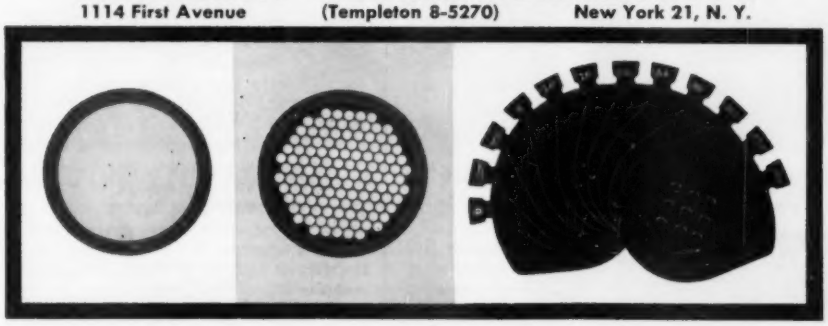

national television, when George V. Denny, Jr., Vice-President of the People-to-People Foundation (and formerly of American Forum of the Air fame), introduced the technical papers with a talk on the promise that international television broadcasting holds for better understanding between nations. Both high-speed photography sessions were enthusiastically attended, with particular interest shown in the film about the Pegasus mobile mount for underwater cinematography and the sequences of a rattlesnake's strike.

Motion-Picture Shorts

With the help of Jack B. McCullough, and through the courtesy of the various producing companies, a very fine group of motion-picture short subjects was assembled for showing at the beginning of sessions. The following titles were seen:

A Chairy Tale and *Carnival in Quebec*, National Film Board of Canada

Blue Danube and *Alpine Glory*, Warner Bros. Picture Corp.

How to Have an Accident at Home, Walt Disney Productions

Magoo's Masquerade and *Matador Magoo*, Columbia Pictures Corp.

Declaration of Independence, Teaching Film Custodians, Inc.

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Photography and the IGY

Fillmore R. Park

At the Awards Session, which is reported in detail below, and after the formal presentation of awards had taken place, a most interesting talk was given by Fillmore R. Park, Senior Research Officer of the National Research Council of Canada, on the role of photography in the International Geophysical Year. By a remarkable coincidence, while Mr. Park had the minds of his audience firmly fixed in outer space, the first news reports were brought in of the successful launching of Sputnik, adding considerable piquancy to the occasion. Excerpts from Mr. Park's talk are given below (with *italics* supplied) and will undoubtedly serve to whet appetites for the full technical paper on this subject which we hope to print in a future issue of the *Journal*.

"*The part which photography will play* in this great scientific enterprise is twofold. The first and most obvious use is to provide a pictorial history of events and to bring to the public a first-hand account of what scientists are doing in the various disciplines. I am quite certain that the members of this Society are fully aware of the opportunities and the problems involved in this work.

"The second application of photography and photographic techniques during the IGY is to provide a convenient medium for the recording of scientific data. In this application the film record is not the end result but only a means to the end. It is this application of photography with which I am most familiar and I would like to take some time to illustrate and describe a number of ways in which film and special photographic techniques are used to record data.

"Either of two basic schemes or principles is usually employed in obtaining a film record of instrumental or observational data. In the first, the information or data, which is generally derived as a time varying electrical signal, is converted to a light signal varying in intensity and/or position with respect to time. This is generally accomplished by using a cathode-ray tube. The varying light signal is focused on the film which moves past the lens at a constant rate, the motion of the film providing a time scale against which the signal is recorded. Since no shuttering action is necessary this scheme, in general, requires a camera of simple design, the complexity, if any, occurring in the electronic circuitry required to display

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the data appropriately on the cathode-ray tube.

"The second method employs time-lapse photography and is generally used in the direct recording of visible phenomena. In some cases the object may move during the exposure thereby providing a record of its motion or track. This is often the situation in astronomical photography. The camera and associated control equipment are more complex in time-lapse photography since there must be provision for accurate timing of a shutter and for film advancement between exposures. In many instances these functions must be performed automatically. . . .

"*The auroral instrumental program* involves the operation of four specially designed instruments; the Auroral Radar, the All-Sky Camera, the Scanning Spectrograph and the Auroral Intensity Recorder. The latter instrument uses punch tape and paper strip recordings but the other three use film as the recording medium.

"*Auroral radar* is operated on a continuous 24-hour basis at four Canadian stations strategically located on a north-south line across the auroral zone. These radars, which operate on a wavelength of 6 meters, were specially designed and built at the National Research Council for this program. By means of an automatic switching arrangement, the receiving antenna samples the north, west, south, and east quadrants of the sky in turn, thus providing information on the direction of the aurora. Two minutes are required for a complete sampling of the four quadrants. The auroral echoes are presented on a cathode-ray tube and photographed by a camera in which the film moves continuously at a rate of one ft/hr. The result is a continuous range-time record on which the signals from the four antenna quadrants are presented in turn. . . .

"*The All-Sky Camera* is an instrument designed to photograph the night sky from horizon to horizon at regular intervals for the purpose of recording visible aurora. When a number of such instruments are spaced less than 500 km apart, the location and distribution of auroral displays can be determined. The instrument consists, essentially, of an electrically operated, time-lapse camera, a spherical mirror and a timing and controlling unit to determine the exposure rate and duration and to provide the time, date and other identifying data that are recorded in each picture. Several such cameras have been built during the past few years by workers engaged in auroral research. In general, commercial 16mm movie cameras were modified for this purpose.

"The National Research Council has designed and built a number of 35mm All-Sky Cameras for use at selected IGY stations. The change from 16mm to 35mm film has been made possible by the recent availability of reliable, electrically operated, 35mm instrumentation cameras. The use of the larger picture has resulted in a considerable improvement in the quality of the photographic record. . . .

"In addition to the 35mm All-Sky Cameras built by N.R.C. there are a large number of 16mm cameras distributed across the country at IGY stations. Some of these are being operated for special purposes in conjunction with other scien-

tific work such as the rocket firing program at Fort Churchill. The Russian scientists have built forty 35mm all-sky cameras for use during the IGY. A total of over 100 all-sky cameras will be in use across the whole world. . . .

"*The Scanning or Patrol Spectrograph* was specifically designed for auroral research during the IGY. This instrument is entirely automatic in operation and is designed to photograph spectra of aurora occurring along a given magnetic meridian of the sky from horizon to horizon.

"Radiation from the aurora passes through the slot in the dome at the top of the instrument and through the fish-eye which focuses the radiation on a narrow slit. This lens combination has the property of focusing the light from the whole 180° field (from horizon to horizon) on the slit. After collimation the light is dispersed by a 600-line/mm grating into a spectrum. The spectrum is brought to focus by an optically high-speed Schmidt camera and is recorded on 16mm spectrographic film. The length of the exposure is determined by a photometer which integrates the amount of radiation falling on the sky lens. Data relating to the exposure, date, station, etc., are brought to focus on the film from behind the Schmidt mirror and together with a calibration step wedge are recorded on the film automatically, at the end of a sky exposure and the beginning of a data cycle. A moonlight eliminator shuts the instrument off if the moonlight becomes too bright. . . .

"An attempt has been made to discuss, very briefly, those IGY programs which employ film and special photographic techniques to record scientific data. The amount of film involved for recording purposes alone, though probably not large in the eyes of the motion-picture industry, is likely to exceed a half million feet for Canada alone. The problem of analyzing all these data is indeed a gigantic task and will take many years to complete."

Arrangements and Entertainment

Early attention by Convention Vice-President Carleton Hunt and considerable careful planning and administration by the Local Arrangements Chairman, A. J. Platt, contributed to an extremely smooth-running and well-organized convention. Jack Platt, who not only had overall responsibility but arranged the details of many of the social events as well, was on the job day and night. His efficient band of helpers included H. L. Ewing, for liaison with the hotel; Joe G. Mullen, who was responsible for both Get-Together Luncheon and Banquet arrangements, and who in addition found time to take care of multifarious emergencies; Edward Stanko, E. T. Griffiths and L. W. Leidy, who kept the registration operation on an even keel; and Herbert Mattelson and George E. Dutch, the auditors, who spent many hours keeping the accounts straight.

Projection matters were most capably managed by Ralph H. Heacock, and Everett Miller, Jack Leahy, Jack Greenfield and James F. Cornell took good care of the public address system and recording. Bill Koch, down from New York, gave the membership desk the best coverage it

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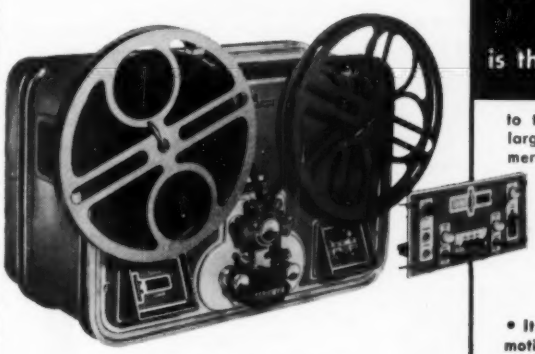

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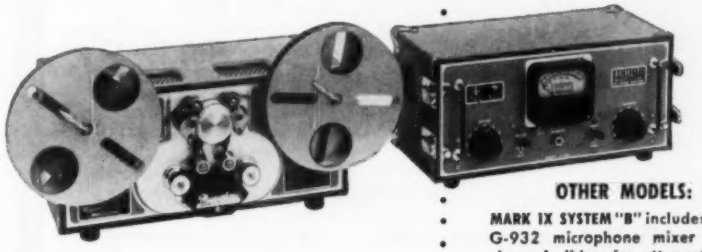

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has had in a long time and besides handing out much information and many applications, netted 20 new members on the spot.

Pressroom activities, under the professional guidance of Hal Rusten, RCA, went ahead swimmingly, especially since the Society was lucky enough at the last minute to enlist the additional help of Len Bidwell. One innovation tried this time was a press conference held at the opening of the convention, at which the President, Executive Vice-President, Engineering Vice-President and Program Chairman met with representatives of the trade and daily press and discussed the details of the papers program.

Social events, in addition to the regular luncheon and banquet, which were held in the hotel, consisted of an informal dinner at what is generally considered to be Philadelphia's finest eating place, Old Bookbinders, and an evening at the Cherry Hill Inn, across the river in Camden, for cocktails and dinner in friendly and comfortable style. Bad weather on Sunday unfortunately curtailed some of the sightseeing tours that had been planned.

The ladies found a full and absorbing program of activities, in addition to the general social events, arranged for them by the Ladies Committee under the joint chairmanship of Mrs. A. J. Platt, Mrs. Everett Miller and Mrs. H. L. Ewing. A fashion show and tea at Strawbridge & Clothier, famous Philadelphia department store, was arranged for one day; a whole day's trip to the antique shops and Pennsylvania Dutch atmosphere of picturesque Bucks County, a day at the fabulous Winterthur Museum, card parties, shopping expeditions and visits to local theatres gave everyone plenty to do, with something to suit all tastes.—*D.C.*

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Society Awards

The Awards Session, one of the traditional features of the Fall Convention, when the Society honors individual members who have made outstanding contributions to the progress of the industry, took place on Friday evening, October 4. One award, the David Sarnoff Gold Medal, was presented separately at a special ceremony during the Get-Together Luncheon earlier the same day.

Honorary Members

Dr. C. J. Staud, Vice-President and Director of Research, Eastman Kodak Co., accepted the award of honorary membership in the Society on behalf of Dr. C. E. Kenneth Mees. The following citation, prepared by the Honorary Membership Committee under the chairmanship of Deane R. White, was read by Norwood L. Simmons, Executive Vice-President:

The contributions of Dr. C. E. Kenneth Mees to the arts and sciences of photography in general and to motion-picture photography are so many that one cannot single out any particular contribution as being outstanding above the many others.

His interest in science dates back to early boyhood. At the age of ten he was greatly impressed by a chemical experiment demonstrated by one of his teachers, and from that time on his greatest interest was in science. His formal schooling, however, emphasized the classics until, just prior to entering the University of London, he attended a technical school for senior boys. There he met S. E. Sheppard, and the two entered University College together. This was the beginning of a lifelong friendship and association. At the College they were drawn together by development of a mutual curiosity about the photographic process. At first they could not find published any satisfactory explanation, but then Sheppard turned up a paper of Hurter and Driffield which laid down the basic principles of photographic exposure and development. This work, however, had been published in 1890, and the two young students soon saw that with the advances which had been made in physical chemistry during the intervening ten years, it would be rewarding to repeat and extend these investigations. Permission was obtained from the University and they undertook the task together. The work which they did was accepted in 1903 as thesis for the B.Sc. degree by research — the first and the last time that such a degree was granted by the University of London.

In their following years at the University Mees and Sheppard continued investigations on the photographic process, and published eleven papers between 1904 and 1907. They were awarded Doctor of Science degrees in 1906 on the basis of these investigations, which were also published as a book, *Investigations on the Theory of the Photographic Process*.

When Dr. Mees had completed his work at the University he joined the small photographic firm of Wratten and Wainwright Ltd. as a partner and joint managing director with his friend, S. H. Wratten. During the six years that he spent with

Wratten and Wainwright Dr. Mees continued his researches and worked out methods for sensitizing the photographic dry plate to all wavelengths of the visible spectrum, thus introducing the panchromatic plates which later made color photography practical. He studied the spectrophotometric characteristics of dyes, evolved methods for the manufacture of light filters and safelights, and worked on plates for photoengravers and spectroscopists.

In 1912 Dr. Mees, at the invitation of George Eastman, came to Rochester, N. Y., to organize and direct a research laboratory for the Eastman Kodak Company. Much of the world's research on the basic theory of photography has been carried out in the laboratory thus founded. During the forty-four years in which Dr. Mees was concerned with operation of the Kodak Research Laboratories, he

Dr. C. E. Kenneth Mees

realized two of his life ambitions: (1) the development of a science of photography and (2) the application of science to industry. Thus, he was not only active in the formulating of some basic principles of motion-picture engineering, but also had a great deal of influence on practical applications. A development of special interest to our Society was the 16mm reversal process of amateur cinematography; later followed by a corresponding 8mm film process. Dr. Mees was keenly interested in color photography and after the introduction of amateur motion pictures, he placed much emphasis on color processes. The result was the marketing of the first Kodacolor system, which produced motion pictures in color by means of 16mm lenticular film. This was soon followed by the Kodachrome process of color motion pictures, and later followed by several other color processes.

Dr. Mees has published some 160 scientific articles and pamphlets, including a number of papers in the *Transactions* and the *Journal* of this Society, and a number of books.

Dr. Mees is the recipient of a large number of honors, medals and awards. That his work is valued on the highest level is evident from his being a Fellow of the Royal Society of London, a member of the American Philosophical Society, and the American Academy of Science. He has been awarded the Draper Medal of the National Academy of Science and the Progress Medal of our Society. Numerous other distinctions have been conferred upon Dr. Mees. He is Honorary Fellow of the Photographic Society of America, Honorary Fellow of the Royal Photographic Society, an Honorary Master of Photography of the Photographers' Association of America, and an Honorary Member of the Association for Scientific Photography.

Honorary Membership was conferred upon E. I. Sponable, with the following citation, prepared by the Honorary Membership Committee under the chairmanship of Deane R. White:

Few men have been able to influence the industries in which they have worked as decisively and as beneficially as Earl I. Sponable.

At the beginning of his career, working with Theodore W. Case, he developed the first commercially successful system of sound on film recording. The success of the Movietone system undoubtedly facilitated the introduction of the other well-known systems of photographic sound recording, which quickly supplanted the disk record for motion-picture use and brought about the most complete transformation that has ever taken place in the motion-picture industry.

During the period of the change to sound. Mr. Sponable was continuously active. He was in consultation with the group at the Bell Telephone Laboratories which was developing the light valve method of recording. He designed the first sound-transparent screen. He supervised the development of lightweight sound newsreel equipment, and set up the largest of all newsreel organizations.

He was one of the first men in the industry to see the possibilities of wide-screen motion-picture presentation. His work in the period prior to 1930 led to the release and exhibition of three feature pictures and newsreels on 70mm film. The first of these was *Fox Movietone Follies* with its accompanying newsreel. It was initially shown at the Gaiety Theater on September 17, 1929. This was followed by two others, *Happy Days* and *The Big Trail*, during the year 1930. One important result of this work was the creation of the 70mm film, which has since found extensive use in scientific and aerial photography, although it was not retained permanently in the motion-picture field.

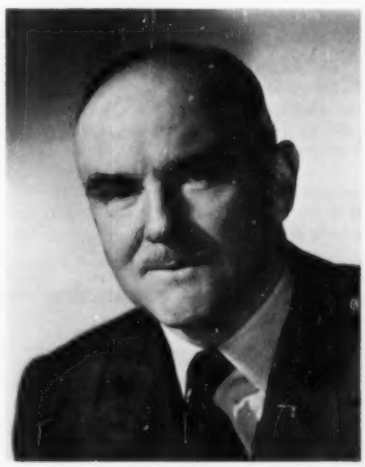
As part of a program of study instigated by the Society's Committee on Wide-Screen Pictures, Mr. Sponable also directed the development of a 50mm film system. A considerable amount of film was photographed in this size, which was finally judged to be near the optimum for use in wide-screen presentations.

Mr. Sponable's other activities have included an extremely thorough survey of all known motion-picture color processes, which led to the development of a practical system of the lenticular film, additive type, and much work in the field of theater television.

He served as President of the Society in 1949 and 1950. His active support during his term of office was important in bringing about the change from the Society of Motion Picture Engineers to the present Society of Motion Picture and Television Engineers.

His role as the technical sponsor of the CinemaScope process is recent and well known. In this case, a rare combination of commercial and engineering vision enabled him to exploit the long neglected anamorphic process at precisely the time when its advantages were of greatest value to the industry. He did much to insure the success of this major change by engineering a good overall system, including improved sound reproduction.

This work has been continued and expanded most recently in the CinemaScope



Earl I. Sponable

55 system, in which he has applied his earlier experience in the use of films wider than 35mm.

The motion-picture industry can rightly attribute much of its advancement over the past thirty years to the engineering skill and good judgment of Earl I. Sponable.

Fellows

Certificates of Fellowship in the Society were presented by Dr. John G. Frayne, Past-President and Chairman of the Fellow Awards Committee, to the following:

H. L. Baumbach	N. H. Groet
E. E. Benham	F. P. Herrnfeld
R. A. Colburn	W. G. Hill
V. J. Duke	W. E. Humm
F. A. Edouart	Brian O'Brien, Sr.
C. H. Evans	B. D. Plakun
H. E. Farmer	W. E. Pohl
W. E. Gephart, Jr.	R. J. Ross
J. C. Greenfield	Petro Vlahos

E. M. Warnecke

Dr. Ralph M. Evans (left) receives the Progress Award from Barton Kreuzer, SMPTE President.

Progress Medal

The following citation, prepared by the Progress Medal Award Committee under the chairmanship of Herbert Barnett, was read by Norwood L. Simmons, Executive Vice-President:

A professional technical organization such as this one is, by definition, a cooperative enterprise. It is a channel through which the combined efforts of many individuals perform a whole gamut of useful functions. Throughout the wide range of accomplishments that result are a number that we are aware of because of the direct benefits we personally receive. Others we know about because we are active in committee work and have seen them develop at first hand. We have become acquainted with still additional ones through regular reading of the *Journal*.

It is these services and the values derived from them that enable us to measure this Society's worth — its utility to its members, to its specialized areas of industry, to engineering and to society at large.

But, in recognizing and accepting these values let us not lose sight of the fact that they take their origin in the contributions of individuals. Let us avoid becoming over-enthusiastic about group functions and the supposed creative powers of committees which are one of the current fads in today's emphasis on management. Let us give reasonable credit to the cooperative efforts of the group but no more.

It is appropriate on this occasion that we take time out from our group activities to recognize the lifetime contributions of an individual whose work represents a significant advance in the development of motion-picture technology; whose personal vigor and enthusiasm for his subject have been a continued inspiration to his contemporaries; and whose patiently recorded observations have become a primary source of scientific information on a highly specialized and currently important subject.

We give this recognition by presenting the top award of this Society—The Progress Medal.

It was the unanimous recommendation of the Progress Medal Award Committee for 1957, endorsed by unanimous action of the Board of Governors, that this year's recipient be *Ralph M. Evans*, of the Eastman Kodak Company.

The Committee's selection of Ralph Evans as candidate for this award is based on his outstanding achievements in the development of color motion-picture films and in the art of color photography generally. And it is based, as well, on his remarkable contributions to the understanding of color through lectures and publications.

Ralph Evans is Director of the Color Technology Division of the Eastman Kodak Company. He has served that company in several capacities, including Supervisor in the Color Process Development Division; Assistant Superintendent of Color Processing and Development at the laboratories; Superintendent in Charge of the Color Control Department; and Director of the latter division since its name was changed to Color Technology Division.

Ralph Evans is a Fellow of four professional societies — the Society of Motion Picture and Television Engineers, The Society of Photographic Scientists and Engineers, The Optical Society of America, and the Illuminating Engineering Society. He is an associate member of the American Psychological Association and holds membership in the Massachusetts Institute of Technology Club of Rochester.

Ralph Evans received an award in August 1955, from the Photographers Association of America for distinguished service to the field of professional photography, and he received the Samuel L. Warner Award from the Society of Motion Picture Engineers in 1949.

He is widely known as a lecturer on color and color photography and has written many scientific papers. A most outstanding talent is his ability to present the physical, psychological and photographic aspects of color in a manner understandable to both engineer and layman.

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The Society is fortunate to have had a candidate possessing the excellent qualifications of Mr. Evans as recipient of this, its highest honor.

Acceptance Address for Progress Medal Award

It does not seem a long time to me that I have been connected with the motion-picture business. In fact it seems only a short time ago that I went to work for what was then the Fox Film Laboratories in New York. I was part of a small group of people who had been trained in the technical aspects of photography and who were among the first to enter the industry. Gordon Chambers and Lauriston Clark had gone to Hollywood; Art Miller and Don Hyndman to New York just before.

It is hard today to realize the state of the art at that time. Much of the negative being shot was still ortho or even blue sensitive and much of it was still being processed by rack and tank inspection methods.

On the other hand Technicolor had already been moderately successful with its old two-color cemented film process and an actual count made two years later turned up 45 other color processes in various stages of invention in the vicinity of New York City alone. It became my pleasant duty at that time to investigate all of them and it was a motley assortment if there ever was one. They ran the range from the fairly good Brewster color process to just a gleam in some inventor's eye.

When I went with Fox they were already working with Eastman on the early process which was also called Kodachrome but which Fox called the Nature Color Process — a two-color process which they abandoned two years later. So from the time I entered the business right up to date I have seen the subject of color photography as uppermost in the minds of many of my associates, in spite of what we would now call the rather crude techniques being used for black-and-white.

It was about this time that sound came into the industry and with sound, as you all know, motion pictures as far as the laboratories were concerned, at least, started to become a really technical subject.

Meanwhile, of course, pan film became generally accepted, rack and tank processing became a thing of the past and the development contrast of positive became relatively fixed, at least within any one laboratory.

Soon after this Technicolor marketed *La Cucuracha* in its new three-color imbibition process — an achievement based on real courage and determination; and they were soon to follow this with *Becky Sharp*, the first really successful full-length feature in color.

It was only a few years from this to the new Kodachrome Reversal films from Kodak and not much longer to the negative-positive color films on wide screens as we know them today.

I shall not bother you with further details. I mention these not because I was associated with them but to point out the terrific pace of the improvements and inventions in this field in recent years. And this pace still continues at the present time, as you all well know.

It is a natural question to ask where we are headed — what lies beyond? Well, I'm not going to say — I don't know. During the whole of my experience to date it has been assumed, almost as an axiom, that what the people want is motion pictures in color. I still believe that this is correct and that black-and-white will be displaced almost completely by color in the professional field just as it has in the field of amateur movies. That it has not yet happened can be ascribed to a great many factors, both economical and technical, to the fact that the big money-making pictures of recent years have not by any means all been in color, and to the fact that black-and-white is used more skillfully as a medium to produce subtle effects. I want to return to this point in a minute, but first I want to try my hand at prophesying a little.

I shall not attempt to guess what terrors and horrors you will dream up to which you will subject the film, but I can perhaps suggest directions in which we may see progress in the near future.

It has been my experience throughout my whole association with the industry that the uses to which film has been put have always been just beyond the capacities of the equipment. The technicians, the engineers, and the manufacturers have always had to run to keep up. This is as it should be and will doubtless continue.

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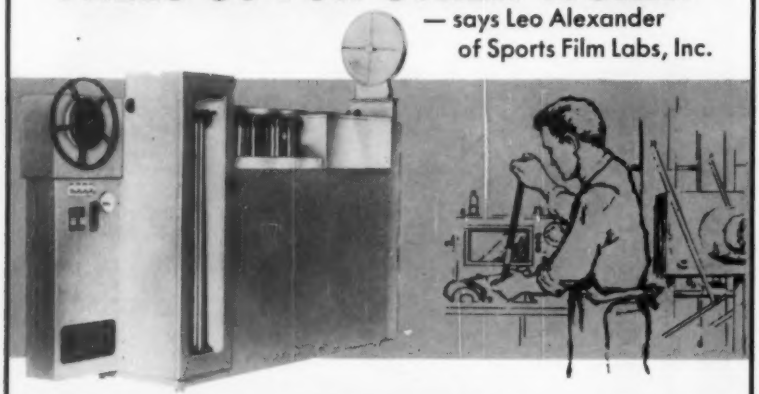

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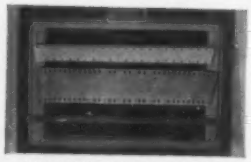

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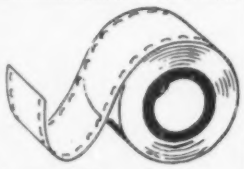

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WRITE FOR COMPLETE MOTION PICTURE EQUIPMENT CATALOG

of present-day motion pictures is the lack of sharpness of the final projected image on the screen. I regard it as even more serious than the low screen brightness of some of our drive-ins. Depending on where you work, you may give your own explanation of why the pictures are so unsharp, the fact remains that they are. I expect and hope to see this condition improve with time and the advance of technology. An image on a motion-picture screen is the final result of a long series of events. At every stage definition can be lost, in almost none can it be regained. Yet if we *could* get a really sharp projection of the images of our present films on a large screen, we would see a realism such as we have never yet even approached. Because we have never approached it, we have learned not to expect it and so have become a little complacent about the whole thing.

For a similar reason I expect to see a change in the *flexibility* of our color processes. Just as sound on film made it impractical to juggle the contrast of release prints, so color has introduced even more rigidity into the handling. The basis of good showmanship, however, is novelty and to get novelty there must be flexibility. In feature pictures we are not dealing with a factual presentation of what goes on in the studio, we are dealing with illusions that are created by the skillful use of the medium. The medium must meet the demands to produce this illusion. I expect it to come, however, by way of materials which will extend the flexibility of printing and process photography, not by manipulation in processing.

In this connection I might point out that even if exact reproduction were what we wanted, we do not yet know enough about how people see color to predict how it should be reproduced for a given situation. We are still working by cut-and-try methods but are much nearer the goal than we were ten years ago.

Along this same line but in a somewhat different direction I am hopeful of great things to come.

In black-and-white photography we are dealing with what amounts to an abstraction from a real scene. No actual scene looks like a black-and-white picture and for this reason much of the realism of the scene is lost. By skillful lighting techniques, camera angles and action much of this realism can be restored *if it is wanted*. The point is that it is not always wanted. When realism is not wanted, then the fact that it is black-and-white rather helps the effect and it is easy to go further by the use of diffusion screens and soft lighting. By careful choice of the amount of realism and with a great deal of help from the soundtrack music it has usually been possible to produce the effects desired.

In color photography it seems almost as though everyone is assuming that realism is the only effect that can be produced. I get the impression sometimes that it has seldom occurred to anyone that color can do anything but be realistic. I grant that there are times when it must be and that is why I predicted that increased sharpness will come. But color is *the* medium by which fine emotional shading can *best* be, not only shown to, but produced *in*, the audience. The color of the sets, the color of the lighting, the color of the costumes, even the color of the make-up can all contribute far more powerfully to the impact of a scene than was ever possible in black-and-white.

And so I shall make as my final prediction that skill in the use of color as an *emotional* factor will gradually develop. When it does, we may find that it is terribly subtle and may find it is beyond our present means of control. When it does come, however, I am convinced that the motion picture will have made another distinct step forward in its power as a medium.—*Ralph M. Evans*

Earl M. Lowry

J. Gordon Jarvis

Journal Award

The following citation was prepared and read by Glenn E. Matthews, Editorial Vice-President, on behalf of the Journal Award Committee:

On behalf of the Journal Award Committee and the Board of Governors of our Society, it is my privilege to announce that the Journal Award for 1956 has been made to Earl M. Lowry and J. Gordon Jarvis, research associates of the Research Laboratories of Eastman Kodak Company, for their excellent paper, "The Luminance of Subjective Black," which was originally published in the August 1956 issue of the *Journal* of our Society. The Journal Award Committee is under the chairmanship of Sidney P. Solow, Consolidated Film Industries, Hollywood.

The Lowry and Jarvis paper describes an experimental technique, gives data obtained using this technique, and supplies the science of photography with important information concerning the response of the eye under a given set of conditions. The

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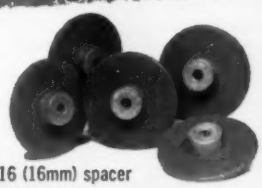

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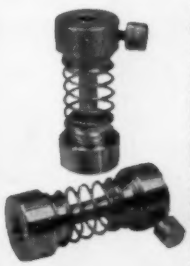

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selection of this paper for the Journal Award recognizes the important contribution made by the authors in regard to the problem of tone reproduction in photography.

The Journal Award was established in 1934 and was first awarded to Dr. Peter A. Snell, the first and only individual to hold a fellowship sponsored by our Society. Papers are selected on the basis of technical merit and importance of subject matter, originality and breadth of interest, and excellence of presentation. In addition to the award, the committee usually selects a limited number of papers for honorable mention. Those chosen by the committee and the Board of Governors for honorable mention for 1956 are:

"Depth of Field and Perspective Considerations in Wide-Screen Cinematography," Robert N. Wolfe and Fred H. Perrin (Eastman Kodak Co.)

"High Efficiency Rear-Projection Screens," Charles R. Daily (Paramount Pictures Corp.)

"The Process of the Magnetization of Magnetic Tape," Walter Guckenburg (Technical University of Berlin-Charlottenburg)

A few words about the winners of the 1956 Journal Award:

Mr. Lowry was born in Saginaw, Mich., and received an A.B. degree from Ohio Wesleyan University in 1917 and an A.M. degree from Syracuse University in 1923. Prior to his association with Kodak, he taught physics at the University of Pittsburgh and at Syracuse University.

In August 1923, he joined the Eastman Kodak Company's Research Laboratories as a physicist and later became supervisor of colorimetry, photometry, and visual sensitometry in the Physics Division. In addition to his researches in the fields mentioned, Mr. Lowry has made important contributions to the development of light filters and wedges. He has published numerous papers on photometric and visual problems.

Mr. Lowry is a member of The Optical Society of America where he served on the Colorimetry Committee. He is a member of the American Standards Association Subcommittee Z58-III, Filters and Polarizers.

The co-author of the 1956 Journal Award paper, J. Gordon Jarvis, has been a member of the Physics Division of the Research Laboratories since he joined the Eastman Kodak Company in November 1946.

Born in Aultsville, Ontario, Canada, Mr. Jarvis received a B.Sc. degree in engineering physics in 1945 from Queen's University, Kingston, Ontario. He was awarded a M.Sc. degree in optics by the University of Rochester in 1951. Prior to his connection with Kodak, he taught physics at Queen's University.

Mr. Jarvis has conducted experimental research in visual sensitometry and special photographic processes. He is a member of The Optical Society of America.

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David Sarnoff Gold Medal

Charles P. Ginsburg

At a special ceremony held during the Get-Together Luncheon on Friday, October 4, the David Sarnoff Gold Medal was presented to Charles P. Ginsburg. The following citation, which was prepared by the David Sarnoff Award Committee, under the chairmanship of William B. Lodge, was read by Axel Jensen, Engineering Vice-President:

The David Sarnoff Gold Medal Award is given to an individual in recognition of an outstanding contribution in the development of new techniques, methods, or equipment which have contributed to the improvement of the engineering phases of television. Preference is given to those developments or inventions which are likely to produce the widest and most beneficial effect on, or improvement in, television.

For his work in the development of a video recorder, the Society of Motion Picture and Television Engineers has selected Charles Pauson Ginsburg as the recipient of the Sarnoff Award for 1957.

Charles Ginsburg was born in San Francisco, on July 27, 1920. He attended both the University of California and San Jose State College, receiving an A.B. degree in mathematics.

While still attending college, Mr. Ginsburg began his professional career as an engineer for Associated Broadcasters, Inc., in San Francisco. In 1952 he joined the Ampex Corp., where he has devoted a good deal of his time to the development of a system for the recording of television video, and associated audio, signals on magnetic tape.

Mr. Ginsburg's analysis of the problem, effective planning, and consideration of alternatives in making a choice of systems elements, that resulted in a practical system, is a demonstration of the mature application of analytical engineering.

In choosing a recipient for the David Sarnoff Award, the Committee recognizes the ingenious application of engineering techniques which Mr. Ginsburg so effectively used in designing a successful monochrome videotape recorder and reproducer.

By his personal contributions and by the supervision and guidance of his associates, he developed a system which successfully withstood daily exposure, beginning in the fall of 1956, to the American television audience.

The development of this system, in the relatively short span of four years, by

Charles Ginsburg, demonstrated once again that there is no substitute for personal enthusiasm, engineering judgment, ingenuity and tenacity.

Samuel L. Warner Memorial

Richard H. Ranger

Axel Jensen, Engineering Vice-President, read the following citation, which was prepared by the Samuel L. Warner Award Committee, under the chairmanship of Gordon E. Sawyer:

The Samuel L. Warner Memorial Award recipient for 1957 is Colonel Richard H. Ranger, a Fellow of our Society.

Colonel Ranger is presented this Award for the invention, development and application of a method of electronically synchronizing sound recorded on magnetic tape to the motion-picture camera.

It is the opinion of this Committee that Colonel Ranger is a most worthy recipient of the Samuel L. Warner Memorial Award because he typifies the individual engineer and the individual's contribution to "sound on film motion pictures." This is in the spirit of the Samuel L. Warner Memorial and the Warner Brothers in the pioneering of sound motion pictures.

Colonel Ranger is a pioneer in the field of electronics. After receiving his B.S. degree from Massachusetts Institute of Technology he continued his education at the Ecole Supérieure de l'Electricité in Paris. He has held outstanding posts with our Government during both World Wars. Colonel Ranger has made many outstanding contributions to the fields of radio, electronics and recording since 1917 and he is presently engaged as President and Chief Engineer of Rangertone in the development of stereophonic recording and reproduction methods.

We all sincerely hope that our friend "Dick" will continue his work for many years to come with the enthusiasm and good nature that have been his.

Herbert T. Kalmus Gold Medal

The citation for this Award, which had been prepared by the Herbert T. Kalmus Gold Medal Award Committee, under the chairmanship of Herman H. Duerr, was read by Axel Jensen, Engineering Vice-President:

The Society of Motion Picture and Television Engineers has selected Wadsworth E. Pohl of the Technicolor Corporation as the

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*1953 Academy of Motion Picture Arts & Sciences Award

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recipient of the Society's Herbert T. Kalmus Gold Medal Award for 1957 in recognition of his outstanding contributions to the development of color motion pictures.

Mr. Pohl was selected because of his inventions and his contributions to basic technical advances leading to new and improved methods of manufacturing color motion pictures. During his 27 years with Technicolor, Mr. Pohl has devoted himself almost exclusively to the recognition and solution of problems inherent in successful color motion-picture production and printing.

Because of his improvements in three-strip color negative processing, contributions to improvements in matrix and blank stocks and their related printing and processing techniques, large-screen presentations of color pictures have been produced by the imbibition process with acceptable quality. He has been instrumental in developing equipment, processes and procedures which facilitated the transition from photographic systems using three-strip silver negatives to systems using integral color negatives for the manufacture of dye transfer prints.

Mr. Pohl, Technical Director of the Motion Picture Division of the Technicolor Corporation of Hollywood, joined that organization in 1930 after receiving a Master of Science Degree from the California Institute of Technology. The improvements which he succeeded in making in the quality of dye transfer prints have been outstanding and have been definitely needed because of the larger area of the theater screens in use for color motion-picture film productions.

Wadsworth E. Pohl

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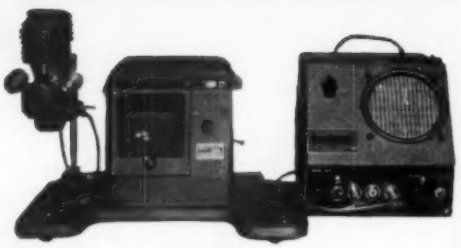

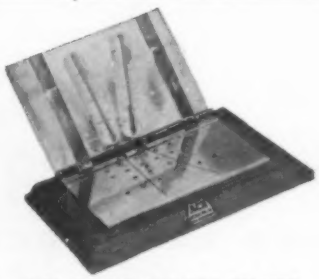

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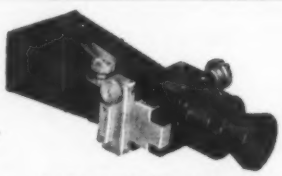

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SMPTE Elections

The results of the 1957 elections for national officers and officers and managers of Sections were announced during the 82d Convention. The following national officers were re-elected for two-year terms beginning January 1, 1958:

Axel Jensen, Engineering Vice-President
John W. Servies, Financial Vice-President
Ethan M. Stifle, Sections Vice-President

For the office of Treasurer, Reid H. Ray, whose term of office as a member of the Board of Governors expires this year, was elected to a two-year term.

Six vacancies on the Board of Governors, as of January 1, 1958, will be filled by Joseph E. Aiken and Deane R. White, from the East Coast area; Don M. Alexander and W. W. Wetzel, from the Central area; and Herbert E. Farmer and Alan M. Gundelfinger, from the West Coast area.

In the Section elections, the following Chairmen and Secretary-Treasurers were elected for one-year terms, beginning January 1, 1958, and members of the Boards of Managers for two-year terms, except where otherwise shown:

Atlanta Section
Chairman: B. M. Loden
Secy-Treas.: Edward E. Burris
Managers, 1958–59: Ivan M. Miles
Earl R. Ruckdeschel
Gerden O. Russell, Jr.

Canadian Section
Chairman: Roger J. Beaudry
Secy-Treas.: Ronald E. Ringler
Managers, 1958–59: Chester E. Beachell
Donald W. Dixon
Norman R. Olding
Managers, 1958: Ron Laidlaw
Ivor B. M. Lomas
Findlay J. Quinn

Chicago Section
Chairman: Howard H. Brauer
Secy-Treas.: William H. Smith
Managers, 1958–59: O. S. Knudsen
Philip E. Smith
Hans C. Wohlrab

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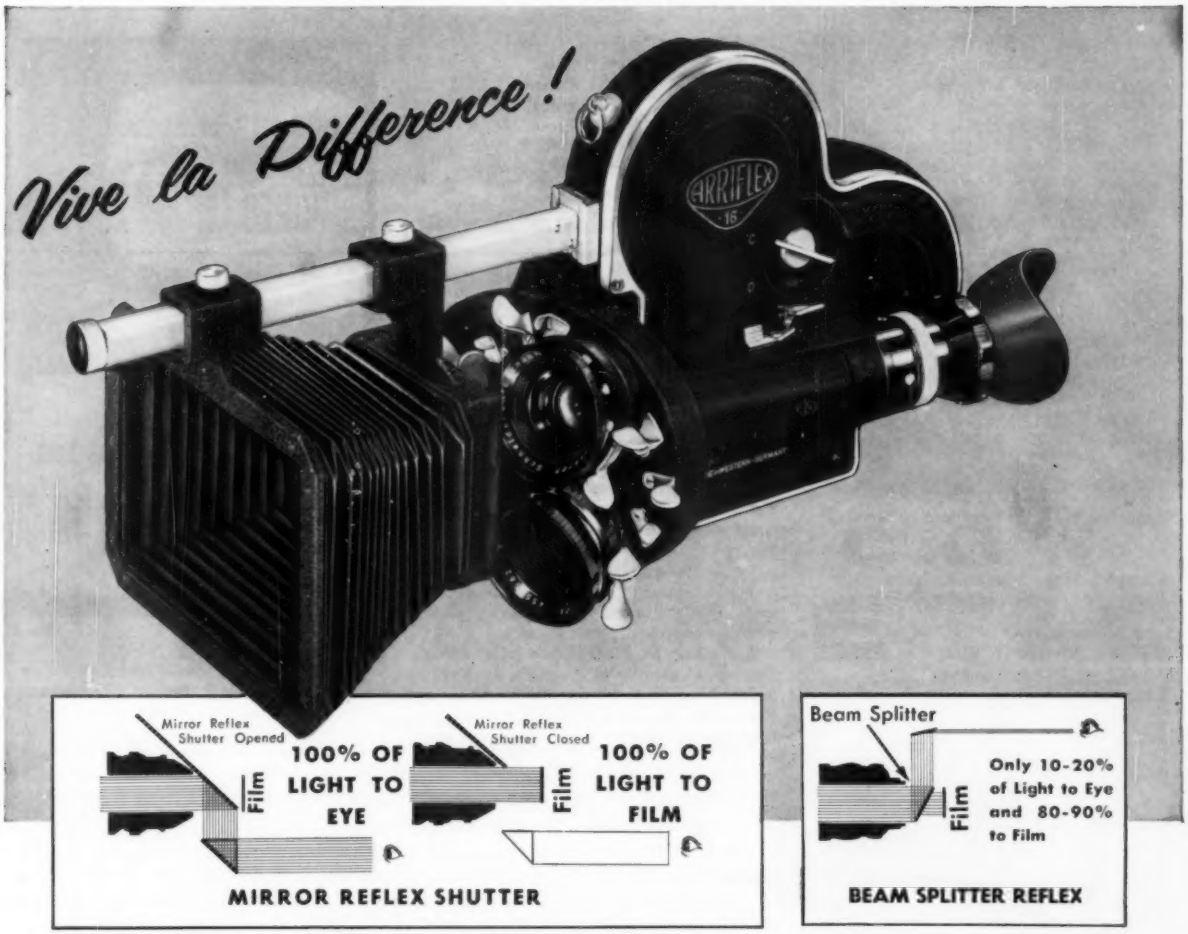

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1. By means of a *mirror reflex shutter* which rotates at 45° between lens and film plane.

   The great advantage of this system is the fact that 100% of the light goes to the film and the eye intermittantly. When the shutter is open there is no interference between film and lens. When the shutter is closed, its mirror surface reflects all of the light to the eye. Result: Easy focusing and viewing on a bright crisp ground glass image even in dim light, or when the lens is stopped down.

   The Arriflex—designed for the professional—uses the mirror reflex shutter, which of course is a much more costly design.

2. By means of a *beam splitting mirror or prism* which is mounted between lens and film. This reflects some of the light (about 20%) to the eye and transmits the balance to the film.

   The disadvantages of this system are:
   The light reflected to the eye is so weak that it is difficult to focus or even sight, unless the lens is wide open and the scene brightly illuminated. In dim light, or if the lens is stopped down, the finder image is so weak it is practically useless. But the light going to the finder is taken away from the film, requiring the f stops of the taking lens to be specially adjusted. The beam splitter permanently in the light path, and close to the film plane, frequently accumulates dust and other foreign matter which may ruin the picture.

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Managers, 1958–59: Hugh Jamieson, Jr.
Philip Wygant
Gordon Yoder

Hollywood Section
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Secy-Treas.: Robert G. Hufford
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Managers, 1958–59: Ernest C. Barkofsky
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Secy-Treas.: Henry M. Fisher
Managers, 1958–59: Joseph E. Aiken
A. Prose Walker
William E. Youngs
Manager, 1958: George F. Johnston

Education, Industry News

Subscription-TV in the Far East

Subscription-TV was inaugurated in the United States September 3, 1957, when subscribers in Bartlesville, Okla., turned on their sets to view a full-length feature. On that date subscription-TV had been in operation in the Far East for three months.

On May 30, 1957, Rediffusion, a form of wire television operated by Rediffusion, Ltd., P.O. Box 121, Hong Kong, was introduced with considerable ceremony. Subscription-TV in the Far East is not, of course, comparable to that in the United States. Rediffusion is the first and only television in Hong Kong, and its primary purpose is to transmit regular broadcasts, not special entertainment for which the public might ordinarily be expected to pay.

According to a statement by Roy G. Dunlop, Controller of Programs for Rediffusion, because of the topography of Hong Kong and the many hills in and around Victoria Island and Kowloon, direct wire

service between the studio and the receiver is the only practical method of supplying television in that area. More than 3,000,000 ft of cable and some 200 amplifiers had to be installed on the Island of Victoria and the mainland area of Kowloon. Linking the two parts of the Colony is an underwater cable more than a mile long. An emergency microwave link has been set up to transmit across the water in case of cable breakage; this is also used on occasion to relay remote pickup programming back to the studio.

A special set is supplied to subscribers or a conventional set can be adapted. Cost to the subscriber is $55.00 a month (Hong Kong — about $10 U.S.). This sum includes hire and maintenance of a terminal unit. If a subscriber supplies his own adapted set the monthly charge is $35.00 (about $6). The initial connection charge in either case is $25.00 (about $4.50).

Programs are shown in both Chinese and English. A survey of the first 1000 subscribers showed that 583 spoke Chinese (Cantonese, 538; Mandarin, 39; Swatow, 6) and 346 spoke English. Seventy-one sets were installed in public places.

The language problem is one that presents unusual technical difficulties. In discussing this problem the Managing Director, Alan Whiting, said, "English feature programs will appear with Chinese subtitles or captions and . . . Chinese programs will be captioned in English. To accomplish this effect . . . white subtitles must be superimposed, not on the film itself but only on the outgoing picture which reaches the TV screen. The process involves previewing each film several times and writing about one subtitle per minute to coincide with the action of the show. The titles must then be edited and painted on cards, later to be photographed and processed and then run through another projector simultaneously with the showing of the program, and so exactly timed and rehearsed that the titles appear on the screen at the right time, in the right sequence. . . ."

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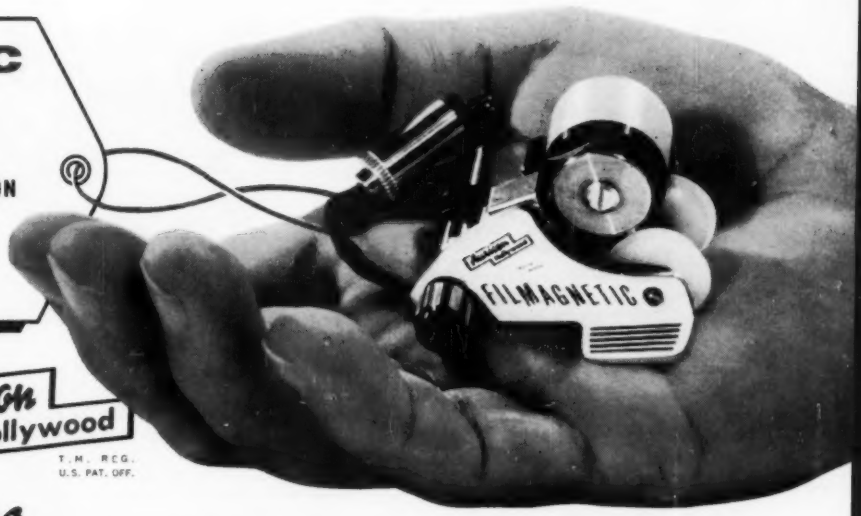

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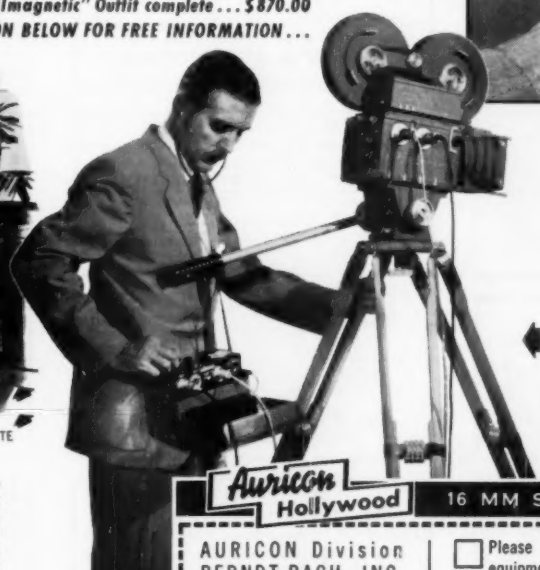

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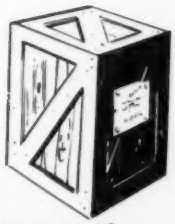

new products

(and developments)

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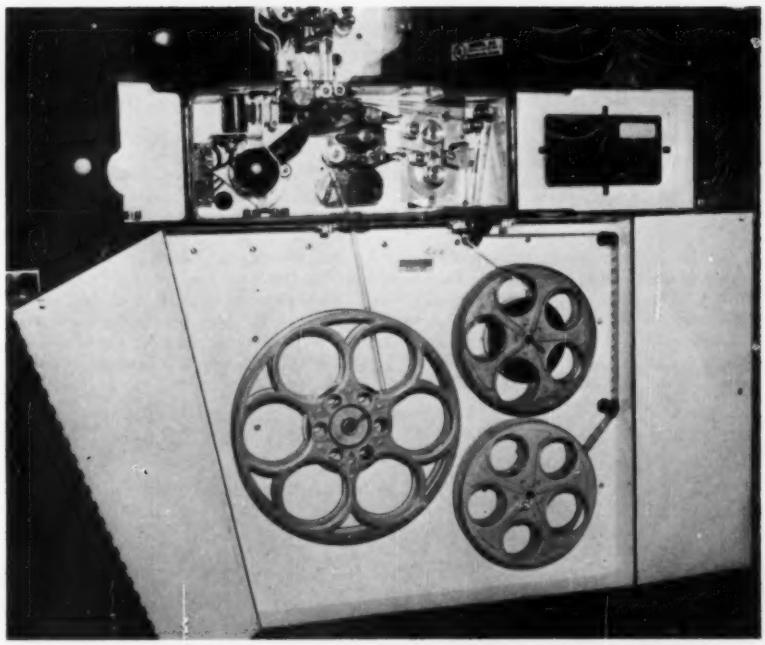

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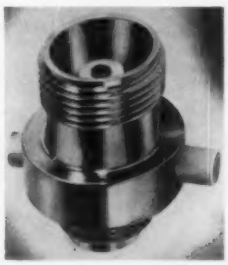

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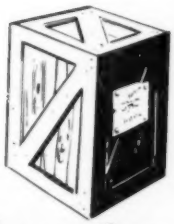

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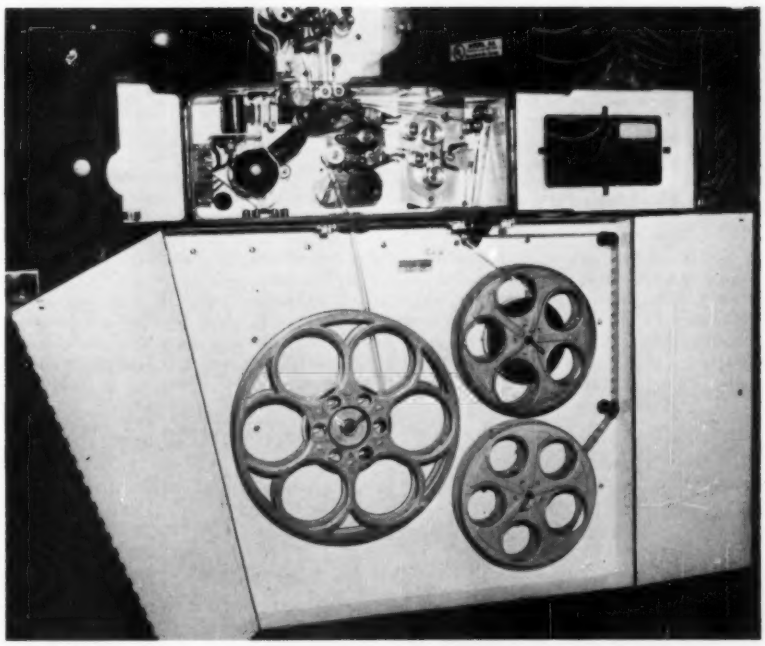

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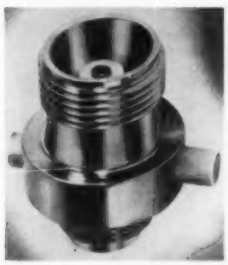

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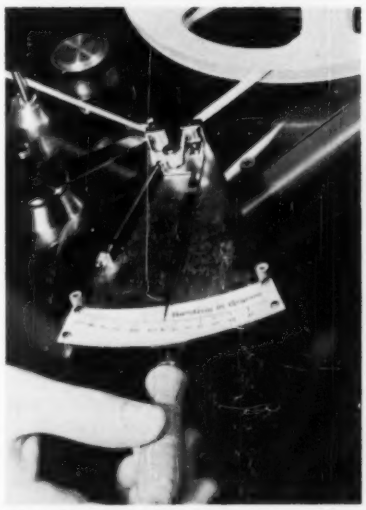

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Shaffer Co., Inc., 849 N. High St., Columbus, Ohio; Signal Equipment Co., 2706 Third Ave., Seattle, Wash.; Southeastern Sight and Sound Corp., 400 Glenwood Ave., Raleigh, N.C.; Springfield Sound, 772 Worthington St., Springfield, Mass.

Each distributor has exclusive representation rights in his particular area and is equipped to sell, plan, install and service all types of industrial TV system.

A 5-channel Memory Unit, Model MU, with Reader and a Keyboard and Punch, Model KP, are announced by Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N.Y. The equipment has been designed for use with the firm's 3-Light Color Additive Head; and also, upon slight modification, for use with the Single Light High Speed Color Additive Head.

The Memory Unit stores the information introduced by the punched tape on the Reader. Fifteen neon pilot lights indicate to the operator when the 15 neutral density glass filters are in or out. The Keyboard has 32 combinations for each color – red, green and blue. There is also a white light or blank for introducing additional information such as lap dissolves, stop and other information. An electric scene counter is included.

The physical punch is shown on the left of the Keyboard while on the right is the same Reader as that used with the Memory Unit which is used to reproduce automatically duplicate tapes. It will also permit corrections of the tape and continue with the accepted information.

Price of the Memory Unit and Reader is $3200.00; and the Keyboard and Punch is priced at $2100.00 f.o.b. New Rochelle.

A 100% nylon velvet has been introduced by Martin Fabrics Corp., 48 W. 38 St., New York 18, for waxing and cleaning film. Reports indicate that this pile fabric is very effective when used either in combination with the several accepted solvents for cleaning or for cleaning film in a dry state. Known as Nylovel, it has lintless pile and is free from sizing and extraneous chemicals. It is woven in broad goods (40 in. wide) and is also obtainable in selected ribbon widths with fused edges. It has been

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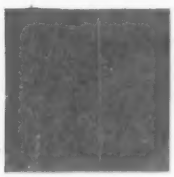

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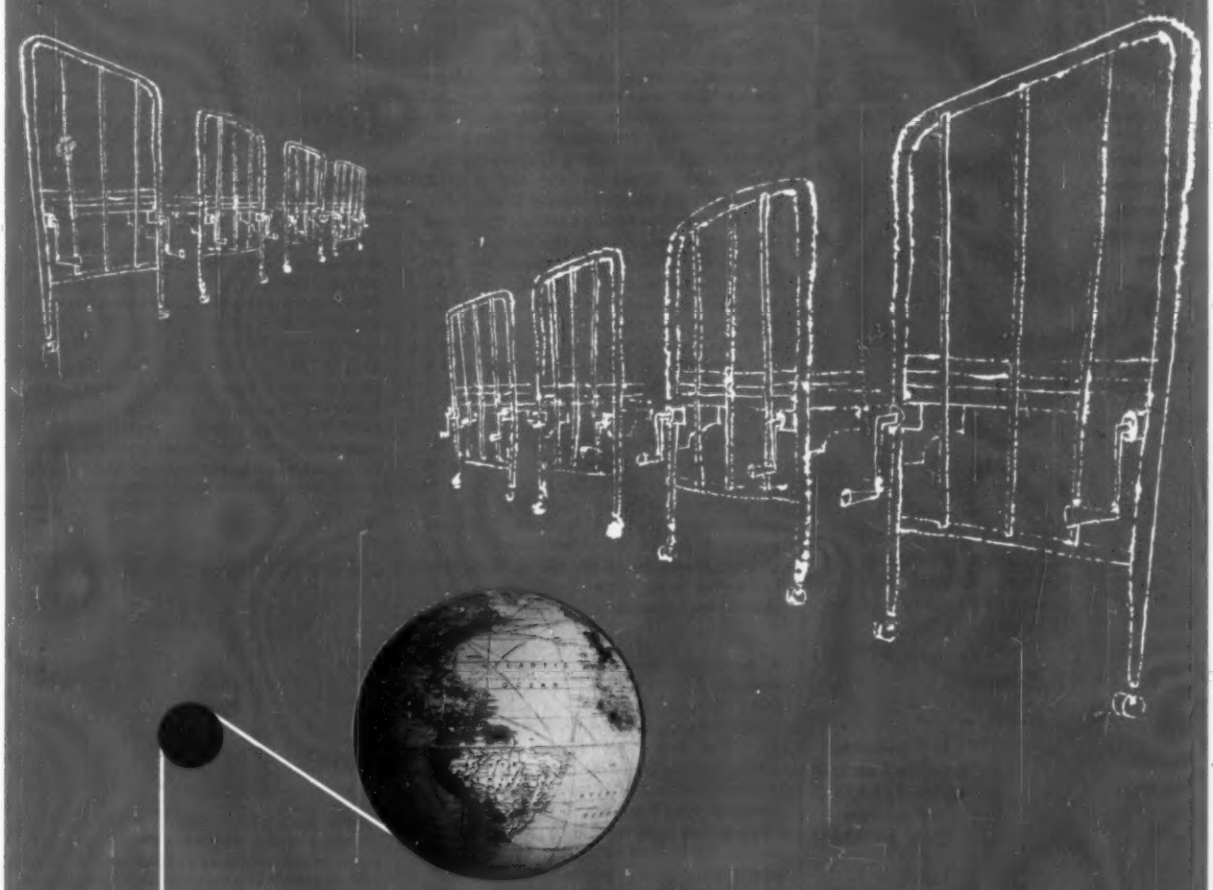

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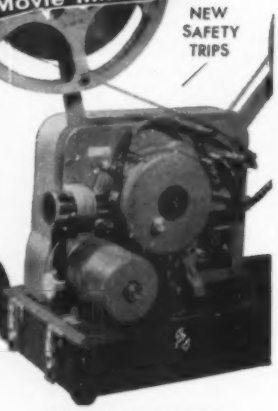

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Phone: Davis 8-7070 SJ

designed as an extremely durable fabric and is marketed as a product which will minimize the scratching of film by absorbing dirt particles into the pile rather than rubbing them against the film. It is available at $3.15 per yard (broad goods). Prices for ribbon widths are available upon request.

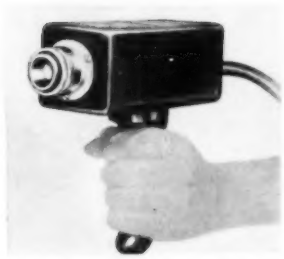
FilMagic Pylon, an automatic silicone lubricator, is an addition to the FilMagic silicone products manufactured by Distributor's Group, Inc., 204 14th St., N.W., Atlanta 13, Ga. It consists of a windowed acetate tube filled with a silicone-impregnated cloth. When in use, the filler is activated by a silicone fluid and the lubricant is fed in controlled amounts through a sleeve of the cloth onto the tape or film. The Pylon is mounted between the feed reel and reproducing parts of the equipment for continuous performance while the machine is operating. A Pylon kit, priced at $2.95, contains one Pylon, a plastic squeeze-bottle of silicone re-loader and 6 sleeves of the cloth.

An all-purpose clamp developed for the Sinar-Swiss interchangeable View Camera (4 by 5; 5 by 7; 8 by 10) attaches to almost any available support, such as tables, fence posts or ladders. The unit weighs 1 lb 14 oz. Distributed in the United States by Karl Heitz, Inc., 480 Lexington Ave., New York 17, to franchised Sinar dealers, it is priced at $44.90.

A successful test of a 2-channel sound system for recording and reproducing from records has been announced by Westrex Corp., 111 Eighth Ave., New York 11. The new type of recording, called StereoDisk, is based on the use of a single stylus to make two separate recordings of identical sound quality in a single groove. The stylus is actuated by two separate sound channels of identical characteristics.

A high-performance oscilloscope preamplifier, Model SPR-100, was introduced at the Western Electronic Show and Convention in San Francisco, August 20–23, by Jerrold Electronics Corp., 23d and Chestnut Sts., Philadelphia 3. Although primarily designed for use with the Jerrold Models 95 and 220 Wide-Band Sweep Generators, the unit is reported to increase the sensitivity and versatility of most oscilloscopes, permitting them to be used in conjunction with sweep generators for sweep frequency measurements. It is said to increase the sensitivity of oscilloscopes by 40 db without adding substantially to the hum or noise content. It is priced at $150.00.

The Jennings RA4 Ceramic Relay is designed with the contacts in a vacuum surrounded by a ceramic enclosure. The unit, weighing less than 1 lb, is said to handle dry circuits in the mv-μa range as well as inductive loads with peak inrush current of 60 amp. Detailed technical information is available from the manufacturer, Jennings Radio Mfg. Corp., P.O. Box 1278, San Jose, Calif.



A miniature TV camera (7.5 by 2.6 in., of high resolution (600 lines, 8 mc), ruggedized (usable picture of 165 db of noise and 20 G of shock) has been introduced as the MC-16-1 by Photo Research Corp., 837 North Cahuenga Blvd., Hollywood 38. The system, consisting of the camera, a control unit for voltages for the camera, and the cable, is priced at $2150.00 f.o.b. Hollywood. In addition a 1-in. vidicon is available at a price of $250.00, a 14-in. monitor at $290.00 and 1-in. f/1.5 lens at $95.00. The camera uses 16mm motion-picture lenses with standard mount. Any focal length, including zoom-type, lenses may be used. Focusing down to a few inches with standard lenses is accomplished by adjustment at the rear of the camera. The camera weighs 2¾ lb.

Photo Research Corp., 837 North Cahuenga Blvd., Hollywood 38, has announced an addition to its line of Spectra Instruments. The new Model C-3 Brightness Spot Meter has a range of from 0.5 to 50,000 ft-L with a reported 5% accuracy of reading. Its spectral response closely matches the CIE luminosity curve. It is powered by three small batteries contained in the handle of the instrument. Battery life is reported to exceed 400 hr operating time. The instrument is 8¼ in. long, 7¼ in. high, 3 in. wide and weighs 3¾ lb. It is priced at $389.75 f.o.b. Hollywood. Eastern representative of Photo Research Corp. is Hoffman Engineering Corp., Old Greenwich, Conn.

The Pan-Cinor 17.5–70mm f/2.4 zoom-type lens for the Camex Reflex 8mm single-lens reflex movie camera was developed to allow continuous through-the-lens viewing and focusing, while changing the focal length and filming without extra finders. Each lens is supplied with a depth-of-field chart and a test film and carries an unconditional guarantee for optical performance. Distributed in the United States by Karl Heitz, Inc., 480 Lexington Ave., New York 17, it is available from franchised Camex dealers. It is priced at $339.00 for the lens. The camera with the lens retails for $539.00.

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Studio Technician. Young man (27), Recent graduate of TV Workshop, finished in top three of class; thoroughly qualified audio engineer, TV cameraman, floor manager, video operator, dolly and boom operator, etc., with knowledge of scenery, special effects, lighting, color TV principles and operations. Seeking job in TV production. Willing to relocate anywhere (Timbuktu if necessary); will accept modest salary to start. Arthur K. Hirshman, 2242 Bragg St., Brooklyn 29, N.Y. Tel: NIghtingale 6-3997.

Motion-Picture Development Engineering. Thoroughly familiar with design, construction and installation of motion-picture film processors and allied laboratory equipment. Scope of 12 yr of laboratory experience ranges from maintenance to plant engineering. Also additional mechanical and refrigeration background. Resumé on request. Apartment 7-B, 283 Avenue C, New York 9. Tel: ORegon 4-8165.

Research or Sales. College graduate with degree in photography and background in engineering desires position in research or sales. Contact George Daugherty, 7413 Heather Row Lane, Houston, Texas.

Audio-Visual Supervisor. Master's degree in education, specializing in production of audio-visual materials. AB in English. Experience in educational television production, planning and production of industrial films. Former audio-visual supervisor for guided missile manufacturer, heading motion-pictures and military presentations. Now engaged in educational film production. Will consider educational or industrial work. Age 32; married. Larry J. Beck, 4303 South 7th St., Tacoma, Wash. Tel: SK 23056.

Sales Representative. Experienced, mature, versatile (editing, cinematography, recording, scripting), supervisory and administrative ability. Former active producer; kinescope recording experience; capable of sales representation on top agency and client level. Excellent references; free to travel and relocate; married; age 34; 15 yr active film experience. Write: c/o Artz, 1365 York Ave., New York 21.

Cinematographer-Photographer. Six yr professional experience in all phases photography, motion-picture, still, color, film editing and production. Two yr photo and cinema school. Presently working as plant photographer in large industrial plant. Age 26, single, will relocate. Desires TV, industrial or production work. Résumé on request. Write: I. Mann, 1123 West Pratt Blvd., Chicago 26.

Assistant Film Director. Experienced location work, scheduling, industrial and educational films, some editing, extensive theatre and writing background, desires production work New York area. Degrees in Journalism and Drama, age 29, veteran, single, excellent references. Resume on request. Write: S. M. Syna, 24 East 97 St., New York. Tel: TE 1-0444.

Motion-Picture Cameraman. Well rounded background in every phase of motion-picture photography, including 3 years as cameraman with leading university. Desire to become affiliated with stable film unit. Married. Age 31. Free to travel. Write: John Viazanko, 1207 Krameria St., Denver 20, Colo.

Executive Management: To utilize professional experience of 24 years as Administrator-Consultant in all phases photo-industry: budgeting, planning, engineering, purchase & installation of equipment, training, operation maintenance, repair, with studios and processing labs. built and operated in the USA & abroad; heavy experience in sales, sales promotion and market surveys throughout the USA in various products. Write: Dana C. Rogers, 405 W. 23 St., Apt. 10A, New York 11; or phone WAtkins 4-8233.

Positions Available

Company Manager. Exceptional opportunity for qualified man with 18 year old Los Angeles manufacturer of film laboratory equipment. Must be over 30, preferably experienced in laboratory equipment manufacture and operation, capable of evaluating product design. Full management responsibility. Require a leader to direct operations, develop equipment, spark sales, keep things moving! Good salary with genuine growth opportunity. Write qualifications and experience: Clyde D. Graham, 672 South Lafayette Park Place, Los Angeles 5, Calif.

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The joy of accomplishment is a universal happiness. Especially in the case of a film which is your creation, born out of hard work and careful planning.

Because Precision's staff of specialists adds its own creative efforts to yours by the use of *specially* designed equipment, and by careful handling and intelligent timing—you might say we are fellow creators, working with you to bring out all you've put into the original...Yes, and maybe more!

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AUTOMATIC TRI-FILM PROCESSOR

UP TO SIX FEET A MINUTE WITHOUT LOSS OF QUALITY!

THE transportable Mark 3 Automatic Tri-Film Processor develops and dries 16, 35 or 70 mm. film at 1½, 3 or 6 feet a minute! Four 400-ft. 16 mm. films can be handled simultaneously—or two 400-ft. 35 mm films—or one 400-ft. 70 mm length. The various film sizes are accommodated by simple adjustments of film separators. Separate temperature control of the processing solution is possible on each tank from 60 to 110 degrees F., within ± 1 degree. The latest high temperature chemical resistant plastics and Type 316 stainless steel are used in all chemical areas. Processing is controlled by a mechanical program unit after the film is loaded into the machine—no special "leader" or continuous tapes, chains or sprockets are used.

The need for stop baths and interbath rinses, normally required in many processes, is virtually eliminated because of a positive squeegee roller design.

A high-efficiency blower system and electrical heating ensure rapid drying in the machine. The Processor is perfect for newsreels, TV news on film, motion picture "rushes" in the field,—in all cases where speed plus quality are essential. Write for literature and quotations.

SPECIFICATIONS

AUTOMATIC TRI-FILM PROCESSOR TYPE T246 Mk3

Size:	54" long, 22" wide, 51" high		
Weight:	400 lbs.		
Power Consumption:	5 KVA maximum single-phase: 110 volts, 45 amps, or according to customer requirements.		
Process Capacity:	1 to 4 rolls 16 mm	length	
	1 or 2 rolls 35 mm	to	
	1 roll 70 mm	400 ft.	
Rate of Processing:	1½, 3 or 6 ft. per min.		

Temperature-controlled solutions and dryer. Daylight operation except loading of film into magazine. Processes perforated or plain film.

Canadian Applied Research Limited

(formerly PSC Applied Research Limited)

1500 O'CONNOR DRIVE
TORONTO 16, ONTARIO, CANADA
PLYMOUTH 5-3371

MEMBER: A. V. ROE CANADA LIMITED & HAWKER SIDDELEY GROUP

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Meeting Calendar

American Society of Mechanical Engineers, Annual Meeting, Dec. 1–6, Statler Hotel, New York.

American Rocket Society, Annual Meeting, Dec. 2–5, New York.

American Institute of Chemical Engineers, Annual Meeting, Dec. 8–11, Conrad Hilton Hotel, Chicago.

American Association for the Advancement of Science, Annual Meeting, Dec. 26–31, Indianapolis, Ind.

IRE, ASQC, AIEE, RETMA, Fourth National Symposium on Reliability and Quality Control, Jan. 6–8, 1958, Hotel Statler, Washington, D. C.

IRE National Convention, Mar. 24–27, 1958, New York.

83rd Semiannual Convention of the SMPTE, including Equipment Exhibit, April 21–26, 1958, Ambassador Hotel, Los Angeles.

Society of American Military Engineers, 38th Annual Meeting, May 20–21, 1958, Washington, D. C.

Armed Forces Communications and Electronics Association, National Convention, June 4–6, 1958, Sheraton Park Hotel, Washington, D.C.

Fourth International Congress on High-Speed Photography, including Equipment Exhibit, Sept. 22–27, 1958, Cologne.

84th Semiannual Convention of the SMPTE, Oct. 20–24, 1958, Sheraton-Cadillac, Detroit.

American Standards Association, Ninth National Conference on Standards, Nov. 18–20, 1958, Hotel Roosevelt, New York.

85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4–8, 1959, Fontainebleu, Miami Beach.

86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 5–9, 1959, Statler, New York.

87th Semiannual Convention of the SMPTE, May 1–7, 1960, Ambassador Hotel, Los Angeles.

88th Semiannual Convention of the SMPTE, Fall, 1960, Shoreham Hotel, Washington, D. C.

89th Semiannual Convention of the SMPTE, Spring, 1961, Royal York, Toronto.

90th Semiannual Convention of the SMPTE, Oct. 15–20, 1961, Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1957 Journal.

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